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Abdominal Aortic Aneurysms: Diagnosis and Epidemiology. The Tromsø study.

Kulbir Singh

Tromsø 2005

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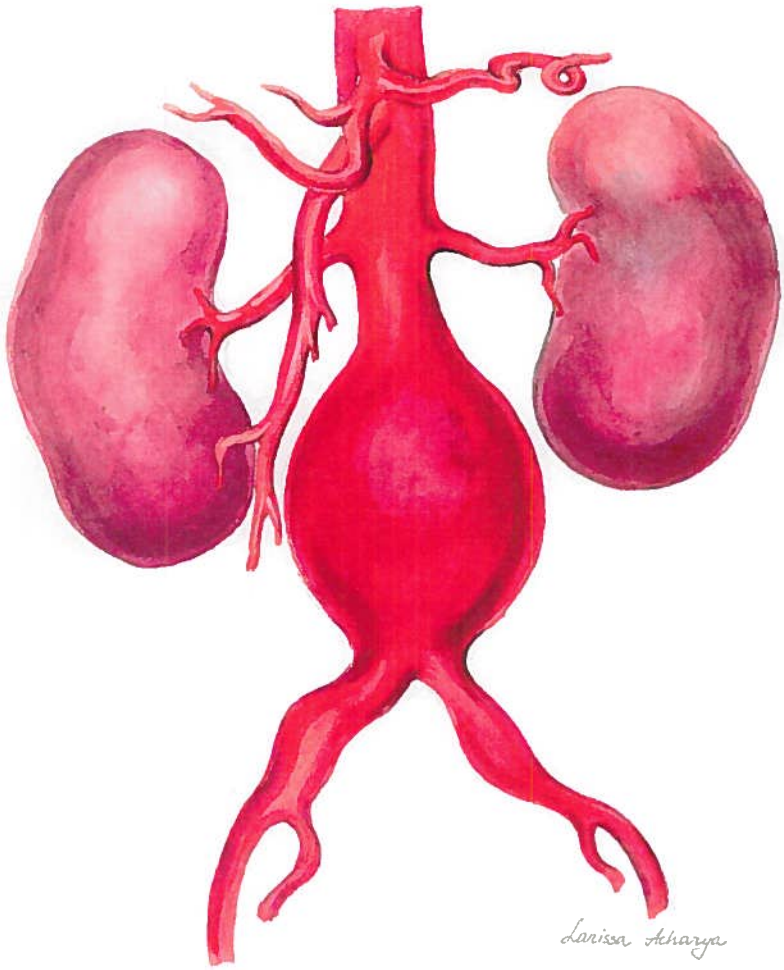

To the participants of the 4th Tromsø Survey and my family

LIST OF PUBLICATIONS

The thesis is based on the following papers, which will be referred by their Roman numerals in the text:

I. Singh K, Bønaa KH, Solberg S, Sørlie DG and Bjørk L: Intra- and interobserver variability in ultrasound measurements of abdominal aortic diameter. The Tromsø Study. Eur J Vasc Endovasc Surg 1998; 15:497-504.

II. Singh K, Jacobsen BK, Solberg S, Bønaa KH, Kumar S, Bajic R and Arnesen E: Intra- and interobserver variability in the measurements of abdominal aortic and common iliac artery diameter with computed tomography. The Tromsø Study. Eur J Vasc Endovasc Surg 2003; 25:399-407.

III. Singh K, Jacobsen BK, Solberg S, Kumar S and Arnesen E: The difference between ultrasound and computed tomography (CT) measurements of aortic diameter increases with aortic diameter: analysis of axial images of abdominal aortic and common iliac artery diameter in normal and aneurysmal aortas. The Tromsø Study, 1994-1995. Eur J Vasc Endovasc Surg 2004; 28:158-67.

IV. Singh K, Bønaa KH, Jacobsen BK, Bjørk L and Solberg S: Prevalence of and risk factors for abdominal aortic aneurysms in a population-based study. The Tromsø Study. Am J Epidemiol 2001; 154:236-44.

V. Solberg S, Singh K, Wilsgaard T and Jacobsen BK: Increased growth rate of abdominal aortic aneurysms in women. The Tromsø Study. Eur J Vasc Endovasc Surg 2005; 29: 145-9.

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Their Northern-Norwegian sense of humour and wit eased our tiresome long days. Thanks to all the colleagues and co-workers for their cooperation and support.

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Kulbir Singh

Tromsø, June 2005

Introduction

Abdominal aortic aneurysm (AAA) is a relatively common, potentially life-threatening condition roughly accounting for one percent of all the deaths in the western world (1). Abdominal aortic aneurysms are usually asymptomatic until rupture. Death from rupture is often sudden and the disease is prone to be misclassified as death from cardiac arrest. Since the introduction of surgical repair of AAA by Dubost and colleagues in 1952 (2), interest in the epidemiology of AAAs has increased. Early epidemiological studies were primarily based on hospital records and autopsies (3-5). An increasing number of screening studies of AAA have been conducted and published (1,6-14) subsequent to the introduction of ultrasound in medical diagnosis in the 1970s.

Already in 1828 Cooper found that AAA is fourfold as common in men as compared to women. Later studies have reported similar results. The mean age of women with AAA is approximately 10 years higher than in men (15). Consequently, most of the screening studies have been conducted in men over 65 years.

Pathophysiology

The 3 layers comprising the normal aorta are the intima, media, and adventitia. Structural and elastic properties of major arteries are mostly imparted by the media, which is composed of smooth muscle cells surrounded by elastin, collagen, and proteoglycans. The development of AAA involves changes in elastin and collagen in the arterial wall. Disintegration of the media with reduction in elastin content is an important histological feature in AAA. AAA is often accompanied by a degeneration of the media and atherosclerotic changes. The degeneration ultimately may lead to widening of the vessel lumen and loss of structural integrity (16). The form of an AAA may be described as fusiform or saccular.

Most AAAs occur in association with advanced atherosclerosis (14,17,18). Atherosclerosis may induce AAA formation by causing mechanical weakening of the aortic wall with loss of elastic recoil, along with degenerative ischemic changes, through obstruction of the vasa vasorum. It is also conceivable that the altered vessel wall and rheological properties induced by an AAA enhance the atherosclerotic process. Many patients with advanced atherosclerosis do not develop AAA, while a few patients having no evidence of atherosclerosis do develop

AAA. A few studies have reported results indicating that aortic occlusive disease and aneurysmal disease are two different pathological entities (18-20).

In 1 to 3% of cases, AAA is supposed to be mycotic, caused by microrganisms of hematogenous origin (21). In these cases local invasion of the intima and media may result in abscess formation and aneurysmal dilation of the vessel. Gram-positive organisms cause mycotic aneurysm most commonly. Chlamydia pneumoniae (22,23) as well as Staphylococcus aureus and Streptococcus species (24) as the infecting agents have been suggested to be associated with AAAs, but the role of these microorganisms in AAA formation is still unclear.

A genetic basis for AAA have been suggested due to the findings of familial clustering of AAAs (25,26) and association of AAAs with hereditary connective tissue disorders such as Ehlers-Danlos and Marfan's syndrome. The risk of developing an AAA is increased by more than ten times if a person has a first-degree pedigree with AAA (25). Although genetic research has identified several defects in the genes coding for matrix components (matrix metalloproteinases) as well as connective tissue proteases and antiproteases (27), the genetic basis for AAA formation is not clear (15).

Definition of abdominal aortic aneurysm (AAA)

The definition of infrarenal abdominal aortic aneurysm (AAA) is usually not a problem in clinical work while dealing with large aneurysms. The problem with the definition is in the border zone in epidemiological studies where there is a need to distinguish between the normal aorta from the abnormal, ectatic aorta or the so-called "small aneurysms". There is no international consensus on the definition of AAA and different studies use different definitions with differing results of the prevalence and risk factors (28). The Ad Hoc Committee on Reporting Standards of the Society for Vascular Surgery defined an aneurysm as: "a permanent localized dilatation of an artery having at least 50% increase in diameter compared to the expected normal diameter of the artery, or of the normal segment proximal to the dilatation" (29,30). The definition described by McGregor et al. defining an AAA being present if the aortic diameter is 30 mm or more, is most widely used (31,32).

Table 1: Proposed definitions of abdominal aortic aneurysm as listed by Moher et al. (33) and re-reported by Bengtsson et al. (5):

Author	Definition
McGregor et al. (31)	Aortic diameter ≥ 30 mm
Sterpetti et al. (30)	Aortic diameter ≥ 1.5 x suprarenal aortic diameter
Collin et al. (32)	Aortic diameter ≥ 40 mm or ≥ suprarenal aortic diameter + 5 mm
ISCVS/SVS (29)	Aortic diameter ≥ 1.5 x normal aortic diameter

ISCVS/SVS: International Society for Cardiovascular Surgery/Society for Vascular Surgery

Diagnosis

Physical examination

An AAA may be obvious (Figure 1) at physical examination. However, clinical examination is mostly inadequate in diagnosing AAAs, and only large ones in slim patients can be detected by palpation (1,34,35).

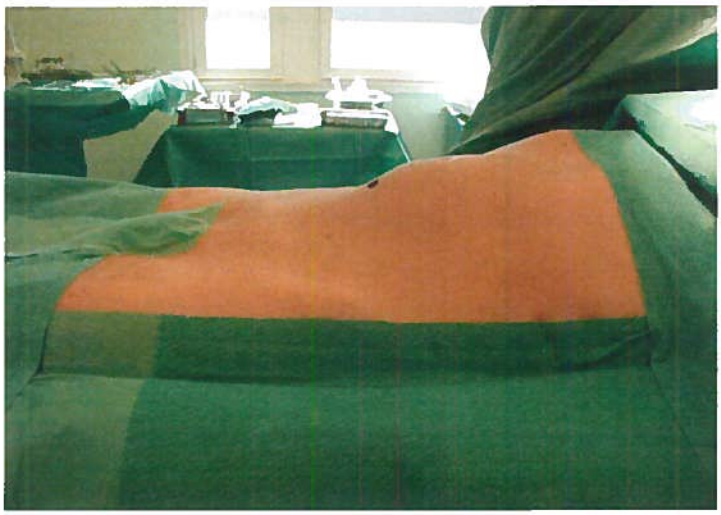


Figure 1: A patient with AAA on the operating table. Sometimes AAA diagnosis is obvious and does not need any diagnostic modality (Courtesy Steinar Solberg, Rikshospitalet).

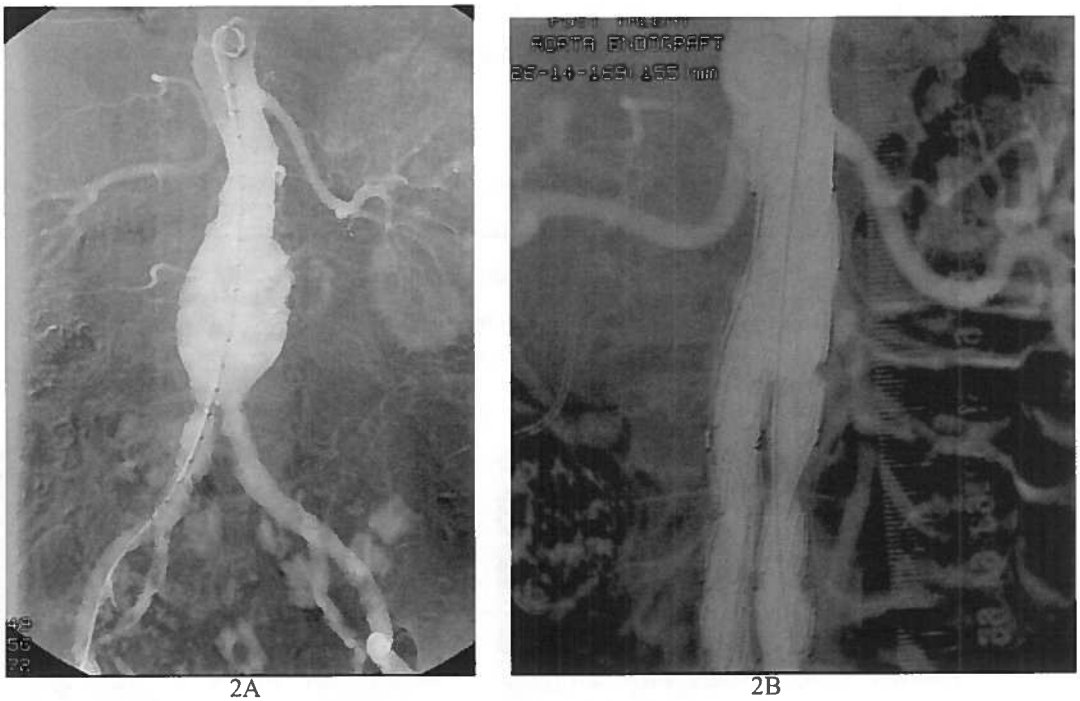
Plain X-ray

Calcification of the aortic wall is necessary to visualize and estimate the aortic diameter using plain abdominal X-ray. Calcifications of the aortic wall are reported in about 75% of the

subjects with AAA (36,37). The only role of plain X-ray in AAA diagnosis today is in follow-up of patients with AAA treated with endovascular stentgrafts.

Angiography

Angiography is invasive and underestimates the diameter of an AAA in subjects with thrombus present. Therefore, it is not suitable for screening purposes. In clinical practice, it is used in the planning of endovascular aneurysm repair (EVAR) or for pre-operative assessment of open surgical repair (38). Figure 2 illustrates the use of angiography in the diagnosis (Figure 2A) and treatment (Figure 2B) of AAA.



2A 2B

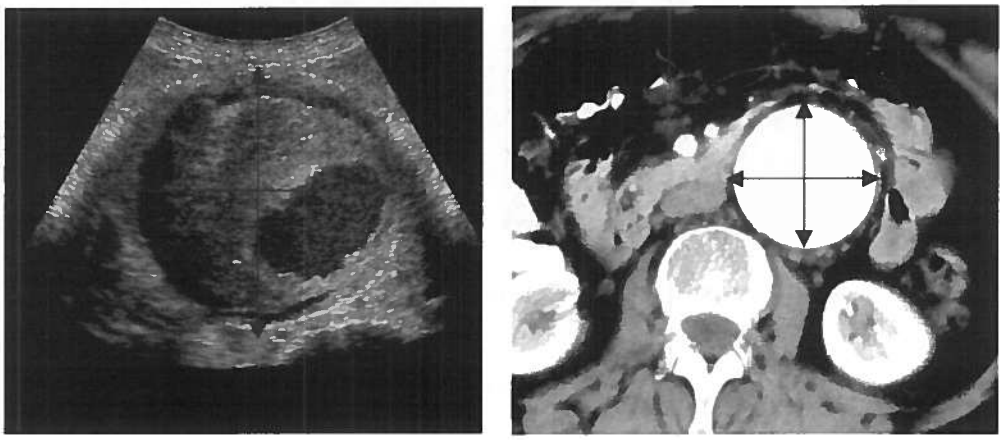
Figure 2A and 2B: Angiography of AAA before and after endovascular stentgraft repair (Own images from Dept. of Radiology, UNN).

Ultrasound

Ultrasound is cheap, mobile, easily available and has practically no complications or side effects. It has a central role in the diagnosis and measurements of AAA, especially in the screening programs (1,10,13,14,39-43) and several studies are published regarding its accuracy (38-40,42,44-54).

Ultrasound is sound pressure waves with frequencies higher than 20,000 Hz. Ultrasound is produced by piezoelectric crystals in an ultrasound probe and transferred to the body via a conductive ultrasound gel. Ultrasound reflects off interfaces between different structures, an effect known as scattering. Some of the reflected ultrasound waves return to the ultrasound probe and are analyzed with image visualization. The frequency of ultrasound used for vascular diagnosis ranges from 2 to 15 MHz. Lower frequencies give better penetration into the body while higher frequencies give better image resolution. Thus, for deeper penetration, relatively low frequency probes are used. Convex probes (2.5-5 MHz) are commonly used for examining abdominal vessels. For the visualization of superficial tissues, high frequency probes are preferred, usually with a linear head. Linear array probes (4-15 MHz) provide good resolution of the plaque and the arterial wall, but provide poor penetration of ultrasound to deep tissues.

B-Mode (Brightness Mode) analyses the intensity, depth and direction of the returning ultrasound signal. A two-dimensional gray scale image with different intensities is constructed from the returning signals. Generally, a high-density structure such as calcification in an arterial wall reflects a high intensity signal that is displayed as white/bright echoes on the screen. The blood in the vessel reflects a low intensity signal and is displayed as black on the screen or image (Figure 3A).



3A 3B

Figure 3 An axial scan of AAA with ultrasound (A) and CT (B). The arrows indicate the measurement sites of anterior-posterior and transverse plane measurements as used in the present study.

Colour Doppler Mode analyses the changes in frequency of returning ultrasound signals and the velocity of moving objects within the specified area is calculated using a formula. An image is built by multiple pixels in the colour box and each pixel is assigned a colour depending on the mean velocity and direction of movement. The colour box overlies the B-mode image and gives qualitative information of blood flow within the vessels.

Power Doppler Mode, being similar to the colour Doppler mode, uses the Doppler principle to display a pulse wave from the designated area within a vessel. A gate is used to sample a signal and the Doppler effect allows it to be converted to pulse wave. The peak systolic and end-diastolic velocities are calculated and displayed. In general, the higher the frequencies are the narrower the lumen. Doppler mode is used for quantitative studies of blood flow.

The Computed Tomography (CT)

Computed Tomography (CT) imaging was developed in the mid 1970s and is now widely available. CT is fast, patient friendly and has the ability to image a combination of soft tissue, bone, and blood vessels. Since its invention, CT imaging has seen massive advances in technology and clinical performance. Today CT enables the diagnosis of a wider range of disease-related structural alterations in the body.

CT imaging combines the use of a digital computer together with a rotating x-ray device to create detailed cross sectional images of the different organs and body parts. With spiral CT, continuous volume acquisition and CT angiography can be used for the diagnosis of vascular disease. For instance, abdominal aortic aneurysms, the renal arteries, the carotid vessels and the Circle of Willis can be quickly imaged with spiral CT.

Inside the covers of the CT scanner is a rotating frame, which has an x-ray tube mounted on one side and detectors mounted on the opposite side. A fan beam of x-ray is created as the rotating frame spins the x-ray tube and detectors around the patient (Figure 4). Each time the x-ray tube and detector make a 360° rotation, an image or "slice" is acquired. This "slice" is collimated (focused) to a thickness between 1 mm and 10 mm using lead shutters in front of the x-ray tube and x-ray detector. Computers are used to control the entire CT system and to reconstruct the raw data into images. Figure 3B shows the axial image of an AAA with CT.

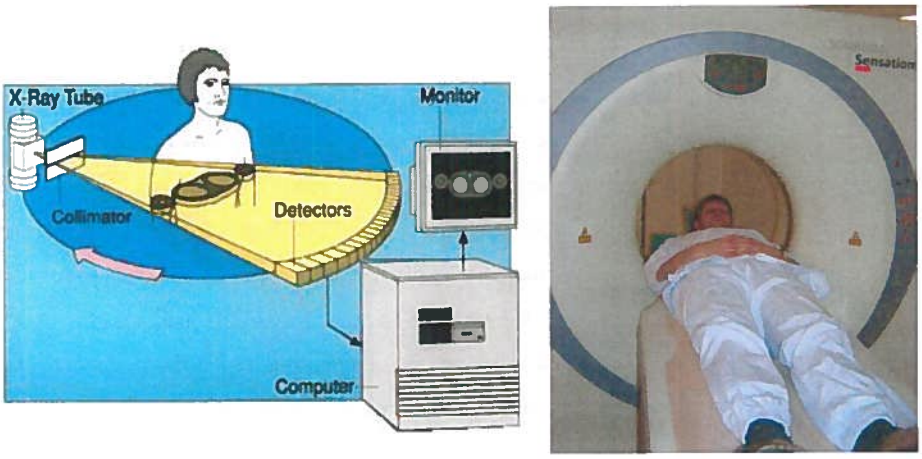


Figure 4: Diagram showing relationship of x-ray tube, patient, detector, image reconstruction computer and display monitor (Source: http://www.imaginis.com/ct-scan/how_ct.asp) and CT gantry (Own image).

CT is used as a diagnostic tool in daily clinical practice. Its use in screening studies is limited due to ionising radiation exposure, need for intravenous contrast medium, immobility, expensive utilization and need of qualified personnel for its use. Several studies have reported on the reliability of aortic diameter measurements using CT, comparing this with ultrasound measurements (45,47,50-52,55-59). Measurement reliability of CT is expected to increase further with the development of multi-detector technology and possibility of three-dimensional imaging, and measurement of true orthogonal aortic diameter (60).

Magnetic Resonance Imaging (MRI)

MRI uses external magnetic energy and radio frequencies to create multi-planar images of the body. Vascular diagnostic imaging by MRI mostly requires the use of contrast media. Its benefits over other modalities include:

1. No exposure of radiation to the patient. 2. Ability to make images in different body orientations (axial, sagittal, coronal and oblique planes). 3. Non-invasive imaging of vessels. Patients with implanted ferro-magnetic metallic devices cannot be examined with MRI. Its safety in pregnant women is not clear. Contrast media used in MRI diagnosis is mainly metabolized in the liver and can therefore also be used in patients with renal failure. Some patients have allergic reactions to the contrast media used to enhance the vascular structures.

The access to diagnostic MRI is increasing and this method appears to have a great potential for imaging the vascular system.

Treatment of AAA

Open surgical repair of AAA has been carried out the last half century, a period of time in which the operative mortality rates have steadily declined, especially among men (61-63). Women are less frequently subjected to AAA repair (64,65).

Endovascular aneurysm repair (EVAR) of AAA was introduced in the early nineties (66) and is still considered investigational. Most studies reporting different mortality rates between the sexes in EVAR had a low number of women included owing to selection (67-71). However, Velazquez et al. (67) and Mathison et al. (72) have shown no significant sex differences in morbidity or mortality in EVAR. The reasons for higher mortality or morbidity for aneurysm in women may be explained by the more challenging anatomy with smaller access vessels for EVAR or surgery and higher age at repair, age being an independent risk factor for mortality and morbidity.

Aims of the study

In the large epidemiological survey in Tromsø during 1994-95, we studied the diagnosis, prevalence and risk factors for abdominal aortic aneurysms in the general population. The present thesis aimed to assess:

- the variability in measuring the abdominal aortic diameter with ultrasound in a population-based study.
- the variability in measuring the abdominal aortic diameter with computed tomography (CT) in subjects with and without abdominal aortic aneurysm.
- how ultrasound and CT measurements of abdominal aortic diameter are related.
- the prevalence of abdominal aortic aneurysm in the general population.
- the risk factors for abdominal aortic aneurysms with emphasis on differences in risk factor profile in men and women.
- the growth pattern of abdominal aortic aneurysms in men and women.

Study population and methods

The Tromsø study 1994-95

The Tromsø study that started in 1974 is a single center population-based prospective study of inhabitants in the municipality of Tromsø, Norway. The aims of the study are to investigate, by means of epidemiological, and clinical research, determinants of chronic diseases in order to assess etiologic significance, and to investigate potentially modifiable determinants that may be developed into preventive or therapeutic strategies. The main focus is on cardiovascular diseases. The study design includes repeated population health surveys to which total birth cohorts and random samples are invited.

The fourth cross-sectional survey of the Tromsø population started in September 1994 and was completed in October 1995, and comprised two screening visits with an interval of four to twelve weeks. All the inhabitants older than 24 years were invited to the first visit (phase I), of which 27159 (77%) attended (Figure 5).

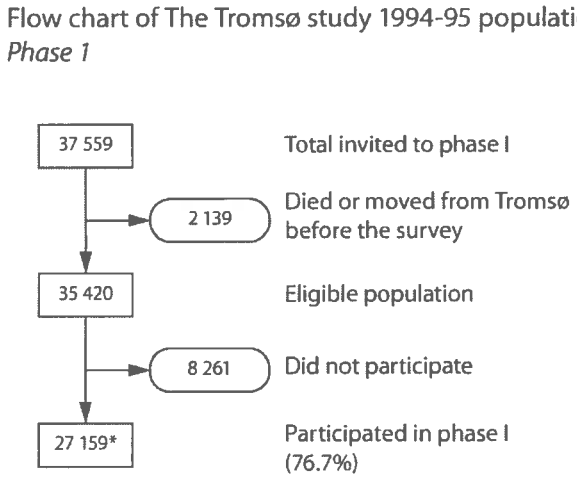


Figure 5: Flow chart of the Tromsø study population 1994-95 phase I

The examination included standardized measurements of height, weight, blood pressure, non-fasting serum lipids, hemoglobin and blood cell counts. Two questionnaires covered previous

and present diseases and symptoms, use of drugs, life style factors (physical activity, smoking, alcohol intake) and dietary habits, and socioeconomic situation (Appendix A).

All subjects aged 55-74 years (born 1920-1939), and representative 5-10% samples of the other age-groups, were invited to the second visit (phase II). The second visit comprised ultrasonographic measurements of aortic diameters, waist and hip circumference, and blood pressure in sitting and standing position, and urine and blood sampling. A total of 6892 subjects, 79% of those being eligible, attended the ultrasound examination. The age and sex specific response rates in the second visit are given in the Table 2. They constitute the basis for all the papers (Papers I-V). The flow chart (Figure 6) gives a description of the survey and the subjects in the different papers included in this thesis.

Table 2: Attendance rate for ultrasound study according to sex and age.

Age* (years)	Men Attended/invited	Percent	Women Attended/invited	Percent	Total Attended/invited	Percent
25-29	40/94	42.6	43/78	55.1	83/172	48.3
30-34	55/100	55.0	71/109	65.1	126/209	60.3
35-39	61/102	59.8	85/139	61.2	146/241	60.6
40-44	54/86	62.8	82/104	78.8	136/190	71.6
45-49	215/270	79.6	97/115	84.3	312/385	81.0
50-54	241/315	76.5	101/105	96.2	342/420	81.4
55-59	701/905	77.5	728/834	87.3	1429/1739	82.2
60-64	712/876	81.3	732/853	85.8	1444/1729	83.5
65-69	638/775	82.3	770/924	83.3	1408/1699	82.9
70-74	551/708	77.8	632/809	78.1	1183/1517	78.0
75-79	117/164	71.3	139/208	66.8	256/372	66.8
80+	9/20	45.0	18/39	46.2	27/59	45.8
Total	3394/4415	76.9	3498/4317	81.0	6892/8732	78.9

* Age is defined as 1995- year of birth.

A few women aged 50-54 from another part of the Tromsø Study (TROST – Tromsø Osteoporosis Study) (73), were examined with ultrasound at their own request.

Flow chart of population examined with ultrasound of the abdominal aorta.
The Tromsø study 1994-95. Phase II

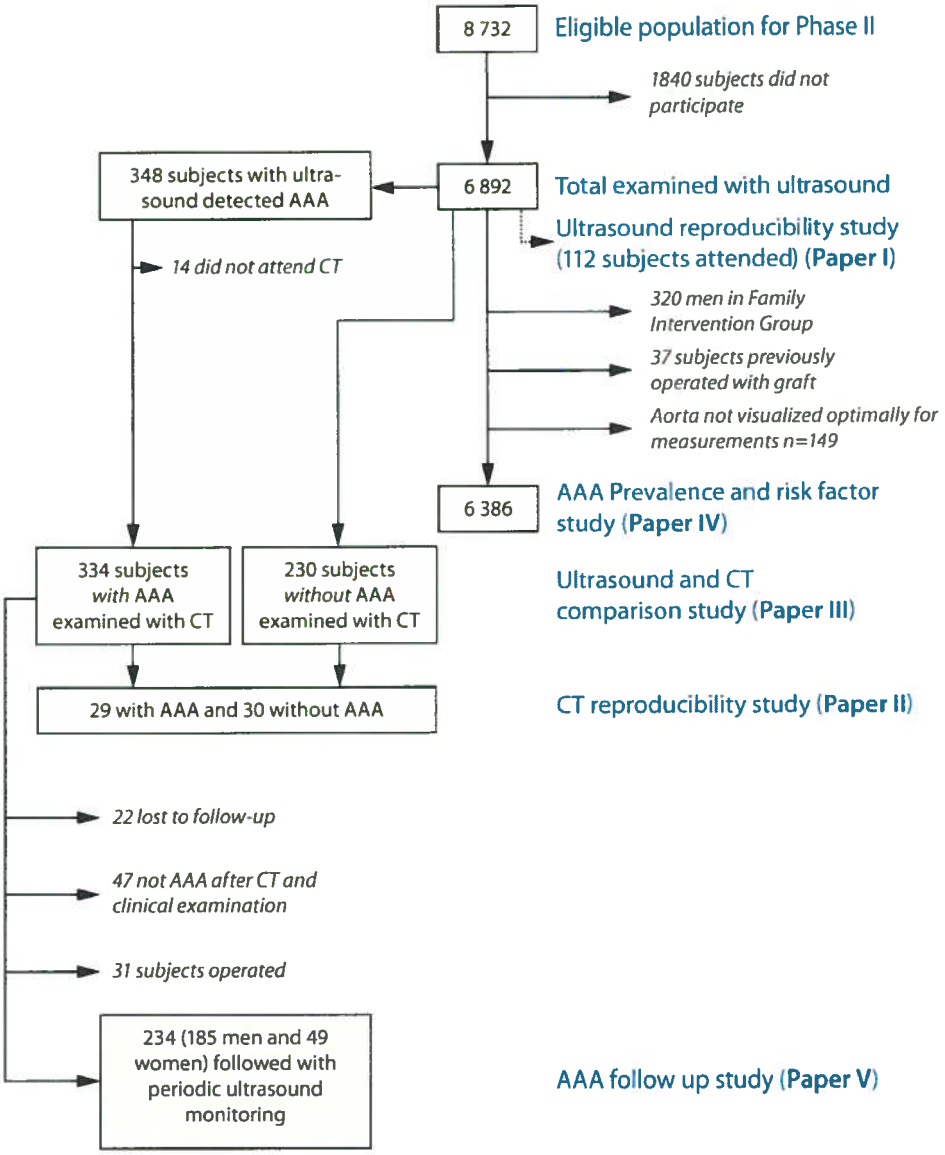


Figure 6: Flow chart of the present study population showing the subject basis for Papers I-V.

Ultrasound of the abdominal aorta

An experienced radiologist (Kulbir Singh) and three trained sonographers (Heidi Bliktun, Laila Hansen and Fred Machielse) measured the abdominal aorta (Papers I, III and IV). The examination was carried out with a 3.5 MHz sector probe (Acuson 128-XP). The abdominal aorta was first visualized in the longitudinal plane and examined from the diaphragm to the aortic bifurcation. The aorta was then examined in the axial plane with scans perpendicular to the longitudinal plane. Aortic diameters were measured at the renal artery level, 1 cm proximal and distal to this level, and at the bifurcation level. In addition, maximal infrarenal aortic diameter was measured. Aortic diameter at the renal level was measured at the origin of the right main renal artery or at the origin of the left main renal artery when the right one was absent or not visualized. Both transversal and anterior-posterior diameters were measured. External aortic diameter was measured with electronic calipers in the anterior-posterior and transversal planes. In addition to abdominal aorta, the diameters of both common iliac arteries were measured. All the measurements were made on-line on images that were frozen in systole and registered on a standard measurement form (Appendix B).

Definition of abdominal aortic aneurysm used in this study

An aneurysm of the abdominal aorta was defined to be present if at least one of the following criteria were met:

i) The aortic diameter at the renal level was equal or greater than 35 mm in either plane.

ii) The infrarenal aortic diameter was at least 5 mm greater than the renal aortic diameter in either plane.

iii) A localized aortic dilatation was present.

CT examination of the abdominal aorta

All the subjects with abdominal aortic aneurysm or other pathology found incidentally at the ultrasound examination were referred to the Department of Cardiovascular Surgery for a clinical consultation and to the Department of Radiology for routine CT examination and measurements of the aortic and common iliac artery diameters. CT examination was carried out with Siemens CT (Somatom HIQ Type 600 Serial Nr. 8349). The examination was done under continuous intravenous injection of contrast medium (120 ml omnipaque 300 mg iodine/ml) and with 10 mm slice thickness and 10 mm increment. Abdominal aorta from the diaphragm to the bifurcation and both common iliac arteries were examined. The external

aortic diameter was measured in the anterior-posterior and transverse planes. The diameter was measured at the renal level, 1 cm above and 1 cm below, as well as at the maximal infrarenal level in both planes. In addition the diameter just before the bifurcation level and the common iliac artery diameters were measured. A total of 348 aneurysmal aortas were found at ultrasound screening, of which 334 were examined with CT. Thus, only 14 subjects (4%) with small AAAs (median max. diameter 28.5, range 22-37 mm), as assessed with ultrasound, did not attend the CT examination (Figure 6).

In addition, 260 subjects without an ultrasound assessed AAA accepted an invitation to CT scanning of their abdominal aorta and common iliac arteries, of which 203 (78%) met. These non-aneurysmal subjects were invited consecutively from the second visit (Figure 6/phase II), without matching for age and sex. In addition, 27 non-aneurysmal subjects attending the ultrasound study and scanned with CT due to accidental findings (abdominal lump or other pathology) were included. Consequently, a total of 230 men and women without an aneurysm, as assessed with ultrasound, were included in the study.

The CT examination in subjects with normal aortas was, as a rule, performed without intravenous contrast medium. All CT examinations were stored in an optic disc and measurements were done on the screen using electronic callipers and registered on standard measurement forms (Appendix B). The precision level was 0.5 mm.

Risk factors for AAA

The analyses of risk factors for AAA are detailed in Paper IV. In brief, two questionnaires collected during the first screening covered previous and present diseases and symptoms (angina pectoris, myocardial infarction, diabetes mellitus, asthma and stroke), use of drugs, life style factors (physical activity, smoking, alcohol intake), dietary habits, and socioeconomic situation. Height and weight were measured and body mass index was calculated (kg/m^2). Blood pressure was recorded in a separate quiet room by a nurse using an automatic device (Dinamap). A venipuncture was performed with the subjects in a sitting position. Serum total cholesterol, high-density lipoprotein (HDL) cholesterol, triglycerides, creatinine and glycated hemoglobin (HbA_{1c}) as well as plasma fibrinogen were analyzed by the Department of Clinical Chemistry, University Hospital of Northern-Norway.

Ultrasound follow-up study

Of the 348 subjects with ultrasound-assessed AAA (Figure 6), 14 subjects did not attend the CT examination or ensuing ultrasound follow-up. Another group of 47 subjects with ultrasound assessed aortic diameters in the border zone were examined with CT, clinically evaluated and excluded from the follow-up study as their aortas were considered within the normal range. Thirty-one patients were treated for their AAA after the screening. Another 22 subjects had either moved to other parts of the country or were unable or unwilling to attend the follow-up. Thus, 234 subjects (185 men and 49 women) were followed with ultrasound surveillance every third or sixth month to assess the growth rates of AAA.

Statistical analysis and ethical approval

The statistical analyses conducted are described in the different papers. The regional ethical committee approved both the main screening (The Tromsø Study) and the computed tomography study.

Summary of papers (I-V) and main results

Ultrasound reproducibility (Paper I)

Methods and materials. Variability of measurements was assessed in the beginning and at the end of the survey period by inviting 120 subjects (80 in the first and 40 in the second period) to a second ultrasound examination within 3 weeks after the first scan. In total, 112 subjects attended this study. All four examiners were blinded to each other's results. In Paper I, the study population is described as randomly selected while in fact it is a representative sample as a consecutive number of subjects attending the ultrasound study were asked to attend the reproducibility study and those giving their consent were issued an invitation.

Results. Variability was similar at the beginning and at the end of the survey period. Both the intra- and interobserver variability were less than 4 mm for all sonographers in measurements of maximal infrarenal aortic diameter, and the variability was similar for measurements in both anterior-posterior and transverse planes. Variability was greater for measurements at the renal than at the aortic bifurcation level. The radiologist had lower variability than the other sonographers.

Conclusions. Ultrasound measurements of the maximal aortic diameter can be obtained with a high degree of accuracy in a population setting.

Computed tomography reproducibility (Paper II)

Methods and materials. From the 334 subjects having an ultrasound assessed AAA, and examined with CT, a random sample of 30 was selected for the variability study. Similarly, from the 230 subjects with normal aortas, ultrasound assessed and CT examined, a random sample of 30 was selected for the variability study. In Paper II, it is erroneously stated that 229 of 287 invited subjects accepted the invitation. However, 203 of 260 invited subjects participated, as detailed on page 22. Due to technical problems, CT data from one subject was not available for readings, leaving 59 CT examinations (29 with and 30 without AAA) for evaluation of intra- and inter-reader variability in measuring the aortic and common iliac artery diameters. All the CT examinations were read on the screen by three radiologists. The same measurements were done again with a minimum three weeks interval for the intra-reader variability. Again, all the radiologists were blinded to each other's and their own previous measurement readings.

Results. Intraobserver variability varied between radiologists, depending on measurement plane and level. The interobserver variability was markedly higher at the bifurcation than at the suprarenal level, and higher than intraobserver variability for measurements at all levels. Both intraobserver and interobserver variability increased with increasing vessel diameter and were greatest in patients with AAA of 40 mm or above. The absolute intraobserver difference of the maximal infrarenal aortic diameter was 2 mm or less in 94% of the intraobserver pairs. The corresponding interobserver difference was 82%.

Conclusions. While making clinical decisions, interobserver variability of CT measurements of aortic and common iliac artery diameter should be taken into account. Assessing change in aortic diameter, previous CT scans should be re-measured simultaneously to exclude interobserver variability.

Comparison of ultrasound and computed tomography measurements (Paper III)

Methods and materials. A total of 564 subjects, 334 with and 230 without ultrasound-assessed AAA, were examined with CT. Of these, 9 subjects without maximal aortic diameter measurements with CT or ultrasound were excluded, leaving 555 ultrasound-CT pairs of measurements of the maximal aortic diameter for analysis. For other aortic measurement levels, a lower number of pairs were available.

Results. As compared to CT measurements, ultrasound slightly underestimated the diameter in non-aneurysmal aortas and tended to overestimate the diameter in aneurysmal aortas. Based

on 555 CT-ultrasound measurements pairs, the absolute differences for maximal aortic diameter measurements were 2 mm or less in 62%, 60% and 77%, 5 mm or more in 14 %, 18 % and 8 % in anterior-posterior, transverse and maximal diameter in any plane, respectively. Variability increased with increasing diameter.

Conclusions. Both ultrasound and CT measurements of abdominal aortic diameter are prone to variability, and neither of these methods can be considered a 'gold standard'. Both methods can be used to make clinical decisions taking variability into consideration.

Prevalence of and risk factors for abdominal aortic aneurysms (paper IV)

Methods and materials. From the study population (Figure 6, n=6892), 506 subjects were excluded, leaving 6386 (2962 men and 3424 women) subjects for analyses. The subjects excluded from the analyses were 37 high-risk patients (previously operated with graft in their aorta), 320 men with hypercholesterolemia (not part of the random sample of Family Intervention Group), and 149 individuals with abdominal aorta insufficiently visualized for ultrasound measurements. The number of ultrasound detected AAAs in paper IV was 337, whereas this number is 348 in all other papers (Papers I, II and III). This discrepancy is due to the exclusion of 11 AAAs (7 in the Family Intervention Group, 2 in the previously graft operated group, and 2 in the group of 149 subjects who had suboptimal measurements of the aortic diameter).

Results. The mean infrarenal aortic diameter increased with age. The increase was greater in men than in women. The age-related increase in the median diameter was less than as compared with the mean diameter, as shown in Paper IV and in appendix C (Appendix C, Table 1). An aneurysm was present in 263 (8.9%) men and 74 (2.2%) women, a statistically significant difference ($p < 0.001$). The prevalence of AAA increased with age. No subjects younger than 48 years had an AAA. Subjects having smoked for more than 40 years had an odds ratio of 8.0 for AAA (95% confidence interval: 5.0, 12.6) as compared to those who had never smoked. A low level of serum high-density lipoprotein (HDL) cholesterol was associated with an increased risk for AAA. Other risk factors were a high level of plasma fibrinogen and a low blood platelet count. Use of antihypertensive drugs (ever use) was significantly associated with AAA, whereas a high systolic blood pressure was a risk factor only in women. Table 2 in Appendix C shows the relationships between smoking status (never-, ex- and current-smokers) and the prevalence of AAA with and without adjustment for possible confounders. Smoking duration seems to be the most important smoking-related determinant for AAA. Furthermore, highly significant associations were found between low

levels of HDL cholesterol (<1.10 mmol/l) and the prevalence of AAA in both men and women (Figure 7).

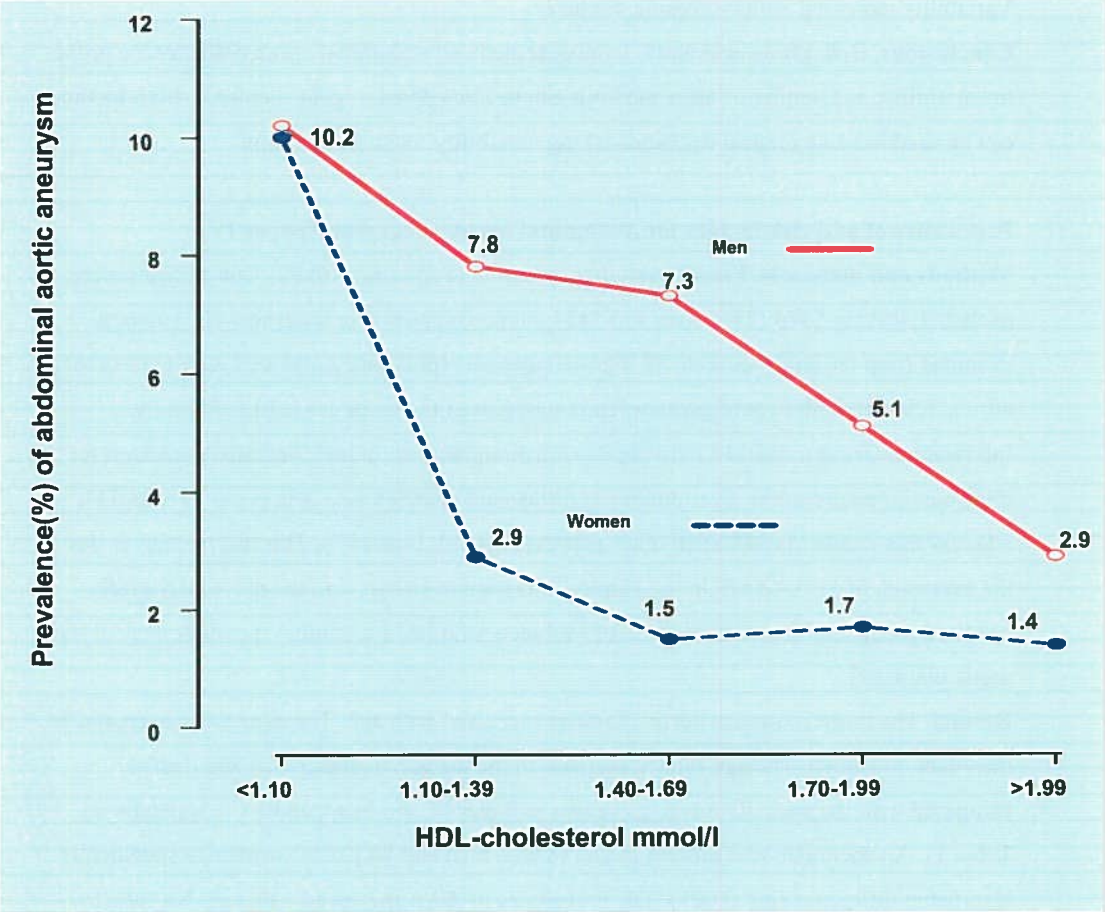


Figure 7. Relationship between serum HDL cholesterol concentrations and prevalence of AAA.

Conclusions. This study indicates that well-known risk factors for atherosclerosis are also risk factors for abdominal aortic aneurysm.

Growth rate of abdominal aortic aneurysms in men and women (Paper V)

Methods and materials. Of the 348 subjects having an ultrasound-assessed AAA, 185 men and 49 women (n=234) were followed with ultrasound examination of their abdominal aorta

every third or sixth month. The follow up period varied from 3 to 90 months, mean 62.4. The number of ultrasound examinations varied from 2 to 31 months, mean 16.1.

Results. The mean growth rate was 1,82 mm per year (1,65 mm and 2,43 mm per year in men and women, respectively). In a weighted, linear regression analysis, the only independent and significant predictors for high growth rate of AAAs were a high initial diameter and female gender ($p<0.001$ and $p=0.003$, respectively).

Conclusions. The study confirms previous findings of a faster growth of large AAAs as compared to the small ones. To our knowledge, this is the first report showing a significantly increased growth rate of AAAs in women as compared to men, adding evidence to those considering female AAAs a more malignant disease. This may influence the frequency of follow-up of AAA, future-screening programs, and the indication for surgery.

Discussion

Methodological considerations

Internal validity

The internal validity refers to whether results from a study are representative or true for the study population (74). Selection bias, information bias and confounding may threaten the internal validity of a study.

Selection bias

Ultrasound reproducibility study (Paper I)

A representative sample of subjects for this part of the study was selected at the beginning (80 subjects) and end (40 subjects) of the study period. The attendance in the early phase was 79 of 80 invited (98.7%) and in the late phase it was 33 of 40 invited (82.5%). Only one subject in the study had an AAA indicating an under-representation as compared to the prevalence in the total population. Since the main aim of the reproducibility study was to assess the variability in measurements of the abdominal aortic diameter in a population screening survey, we do not believe that this selection biased the results. However, due to the small number of AAAs the generalizability of the findings may be questioned.

The ultrasound and CT comparison study (Paper III)

The study population for this paper consisted of 334 men and women (of 348 eligible) with ultrasound assessed AAA and examined with CT. Only 14 subjects (4%) did not attend the

CT examination and should not affect the outcome. In addition, 260 consecutive subjects with ultrasonographically assessed normal aortas, accepted the invitation to the CT examination. Of these 203 (78%) attended. For the comparison of measurements with ultrasound and CT, we further added a group of 27 subjects, with ultrasound assessed non-aneurysmal aortas, which had a CT examination due to accidental pathology. Since we have compared the measurements of aortic diameter with ultrasound and CT, there is no reason to believe that somewhat biased population selection had any profound effect on the outcome. However, the over-all results may be more representative for subjects with AAAs than in the general population, due to the high prevalence of AAA in this subgroup.

Prevalence of and risk factors for abdominal aortic aneurysms (paper IV)

Although the overall attendance rate (79%) in our study was high, the age-specific attendance rates in the youngest and oldest age groups were lower (Table 2). The majority of our population belonged to the age groups 55-64 and 65-74 (in 1994), where all the subjects were invited, with attendance rates 83% and 79%, respectively. As discussed in Paper IV, subjects who attended the first screening of the study but did not attend the ultrasound examination (in 55-74 years cohort), were more frequently current smokers and had lower serum HDL cholesterol levels, but similar blood pressure and even lower total serum cholesterol as compared to those who attended the ultrasound examination. The major concern about non-response bias in our study is connected to the 9% of this eligible population in 55-74 years cohort, who were never examined. We have no direct information about this never attendee group except for age and sex.

Subjects who participated in the first screening, but did not attend the ultrasound examination, are different from the group of never-attendees since they have shown the will to participate in the study. Several studies have found higher levels of cardiovascular risk factors and cardiovascular disease among non-attendees than attendees (75,76). This is probably an important source of bias especially in the older age-groups, who may not attend due to sickness and ensuing disability (77). It is unlikely that lower attendance rates in the younger age groups (below 55 years) have caused underestimation of AAA since aneurysms rarely occur in these age groups. Otherwise, selective attendance of healthy elderly having low levels of risk factors and no AAA may cause underestimation of both prevalence of AAA and related risk factors.

Diagnostic bias

Both possible risk factors for AAA (except for age and sex) and measurements from the ultrasound and CT examinations (both aortic diameter and the presence or absence of AAA) are measured with some degree of error. This gives possible information bias. However, the consequences of these errors differ. If the measurement error for one variable depends on the values of the other variable, the misclassification is differential, and the observed relationship may be stronger or weaker than if no misclassification had taken place. If the measurement error for one variable does not depend on the values of the other variable, the misclassification is non-differential, and the strength of the relationship is usually attenuated (74). Most errors related to ultrasound examination can be expected to be random and independent of exposure information. However, systematic differences in measurements of abdominal aorta occurred between the four observers in the ultrasound reproducibility study (Paper I) and between the 3 radiologists in the CT reproducibility study (Paper II).

Difficulty in ultrasound measurements of aortic diameter in subjects with obesity and excessive bowel gas may contribute to misclassification of AAA as discussed in Papers I and III. On the other hand, obesity is a positive factor for measurement and assessment of aortic diameter with CT (Papers II and III). In the main epidemiological study (Paper IV), ultrasound classification in normal or aneurysmal aortas was not possible in 147 subjects (2.1%) due to suboptimal visualization of aorta.

Uncertainty in the diagnosis of AAA may be another source of concern. There is no consensus on the definition of abdominal aortic aneurysm, and different definitions are used in the published studies (28).The most widely used definition of AAA is ultrasound measured maximal infrarenal aortic diameter of 30 mm or larger. In our study, we wanted to increase the sensitivity of detecting AAA and, therefore, used a strict definition of: i) 5mm or greater maximal infrarenal aortic diameter than measured at renal level as well as ii) localized aortic dilatation and iii) renal aortic diameter of 35 mm or more. It was more difficult to measure renal aortic diameter than maximal infrarenal diameter. Very few subjects had a diagnosis of AAA based on renal aortic diameter of 35 mm or more alone.

The uncertainty in measuring the aortic diameter with both ultrasound and CT (Papers I-III) may have lead to misclassification into aneurysmal and non-aneurysmal aortas. A total of 47

out of the 334 subjects classified as AAA with ultrasound were reclassified as non-aneurysmal after CT examination and clinical evaluation (Paper V). On the other hand, 5 of the 230 subjects with ultrasound assessed non-aneurysmal aortas, had an AAA as classified by CT (results not published earlier), which gives a positive predictive value (PPV) of 86% and a negative predictive value (NPV) of 98 % (Table 3).

Table 3: Subjects with and without ultrasound assessed AAA, re-examined with CT and reclassified into aneurysmal or non-aneurysmal according to CT.

CT / Ultrasound	AAA	Non-AAA	
AAA	287	47	334
Non-AAA	5	225	230
			564

The fact that 47 (14.1%) subjects with ultrasound-detected AAAs were reclassified into non-aneurysmal group after CT and clinical evaluation emphasizes the uncertainty of classifying aneurysms based on ultrasound. To study how sensitive our results with regard to prevalence were for different definitions of an AAA, we also classified the population into non-aneurysmal or aneurysmal aortas by ultrasound-measured maximal aortic diameter at different cutting points (> 29 mm, > 34 mm or > 39 mm) (Paper IV). We found that the prevalence of AAA, when applying the strict definition of aneurysm used in the present study, was quite similar to the prevalence defining an AAA as a diameter with maximal aortic diameter of 30 mm or greater (Table 1 in Paper IV).

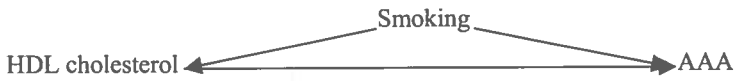
Confounding

The associations between exposure and outcomes may be distorted by a third variable related to both the exposure and outcome, the confounding variable (74). Age and sex are very likely to be confounding variables, and the analyses are usually performed stratified and/or adjusted for these two variables. The confounder must be both statistically associated with the exposure variable and an independent predictor (a risk factor) for the outcome (i.e., it must predict the outcome even in persons who are unexposed). Furthermore, the exposure or the disease must not affect a confounder. For example, it cannot be an intermediate step on the causal path between exposure and the disease (74). In Paper IV and Paper V, the observed

associations between exposure to risk factors and outcomes should be looked upon as statistical associations. This is particularly true when it comes to results from the cross-sectional study presented in Paper IV.

In this study, statistical methods such as multivariate analysis and stratified analysis (by sex, age, BMI) have been applied to examine the effect of possible confounders. We added a number of possible confounders to the models while analysing the risk factor associations in Paper IV and examined their contribution by means of changed estimates of odds ratio (for example HDL cholesterol and total cholesterol).

Known association between low HDL cholesterol and smoking and AAA may illustrate confounding in the present study. Smoking can be considered a confounder when exploring the relationship between HDL cholesterol and the AAA prevalence. This is because smokers are known to have low levels of HDL cholesterol compared to non-smokers (78) and smoking is an independent risk (in fact accepted as causal) factor for the development of AAA.



When adjusting the relationship between HDL cholesterol and AAA prevalence for smoking, there was still a significant association between HDL-cholesterol and AAA; indicating that HDL-cholesterol has an independent effect. However, we do not measure smoking (or any of the other variables except for age and sex) perfectly, and some residual confounding may still be present due to the uncertainty in measuring the smoking variable in the study. The results do, however, indicate that some of the associations for AAA found to be statistically significant in the age-adjusted analyses were in fact confounded by other risk factors (e.g., the associations with white blood cell count and physical activity in leisure).

The associations of plasma fibrinogen level and blood platelet count may in fact reflect the effect of the disease on the exposure variable. This is an example of a variable that is affected by the disease, and therefore not a confounder. As discussed in Paper IV, an aneurysm may cause turbulence in blood flow and activate the coagulation system. The observed association between increased levels of plasma fibrinogen and lower levels of blood platelet count, and AAA in the present study may reflect this. It is also possible, however, that the high level of

plasma fibrinogen reflects inflammation. In order to identify cause and effect of aneurysm and high plasma fibrinogen level, prospective studies are needed.

External Validity

The population in Tromsø does not differ noteworthy from the Norwegian population with respect to age and sex, discussed elsewhere (73). The present study population is, however, dominated by men and women aged 55-74 years, and our findings may not be valid for other age groups. Our study shed some new light on important aspects of the diagnosis and epidemiology of the AAA. However, as the following discussion will show, our findings also confirm many results from previous similar studies. It is, therefore, reasonable to believe that our conclusions have external validity.

Discussion of the main findings

The main findings of our study are discussed in detail in the papers that form the bases for this thesis (Papers I-V). In the following, only a few selected topics not discussed above will be highlighted.

The prevalence of AAA

The over-all prevalence of AAA in the population is probably a somewhat conservative estimate taking into account an increasing incidence of the condition with aging. However, as shown in Table 4 (below), the prevalence of AAA according to our study is similar to the major published studies from the Western world, although study designs vary.

Table 4. Prevalence of abdominal aortic aneurysms in major published studies including the present study.

	First Author	Place	Study type	Attendance rate (%)	Age	Sex	N	Prevalence (%)			
								>29mm	>39mm	>49mm	>35mm
Studies with both men and women participating:											
1.	Singh (Paper IV)	Norway	Population sample	79	25-84	M	2962	8.2	2.3	-	
						F	3424	1.7	0.4	-	
2.	Pleumeekers (41)	Netherland	Population sample		>55	M	2217	-	-	-	4.1
					>55	F	3066				0.7
3.	Rosenthal (79)	USA	GP	100	28-88	M/F	189	1.1	-	-	
					70-74	M	368	-	2.4	-	
4a.	Scott (80)	UK	GP	-	65	M	613	5.1	1.6	0.7	
					65	F	761	0.4	0.1	0	
				59	65-80	M	3345	7.9	2.5	1.3	
					65-80	F	4225	1.4	0.3	0.2	
4b.	Scott (81)	UK	GP	59	65-80	M/F	7200	4.3	-	-	
						M	1947	7.8	-	-	
						F	2290	1.4	-	-	
5.	Simoni (11)	Italy	GP	59	65-75	M	741	8.8	4.3	-	
					65-75	F	860	0.6	0.1	-	
6.	Akkersdijk (12)	Netherland	Pop.referred for US		>50	M/F	4026	4.9	-	-	
						M	1717	7.7			
						F	2309	2.9			
7.	Lederle (13)	USA	Veterans Affairs		50-79	M/F	73451	4.6	1.4	-	
						F	1885	2.5	0.3	-	
8.	Alcorn (14)	USA	Population sample		65 and over	M/F	656	5.8			
						M	1956	14.4			
						F	2785	6.2			
Studies with only men participating:											
9.	Bengtsson	Sweden	Population sample	75	74	M	364	8.5	3.3	2.2	
10.	Collin (1)	UK	GP	52	65-74	M	447	4.2	2.2	0.4	
11.	Holdsworth (6)	UK	GP	79	65-79	M	628	6.4	-	1.6	
12.	Krohn (82)	Norway	HO	47	60-82	M	1256	7.3	1.8	-	
13.	Lindholt (7)	Denmark	GP	76	65-73	M	3344	4.2	-	-	
14.	Lucarotti (8)	UK	GP	79	65	M	4232	-	2.5	0.6	
15.	Morris (83)	UK	GP	73	50-64	M	1776	2.3	-	-	
				75	65-79		1061	8.8	-	-	
				64	>80		193	11.9	-	-	
16.	O'Kelly (9)	UK	GP	76	65-69	M	538	-	0.9	-	
17.	Smith (10)	UK	GP	76	65-75	M	2597	8.4	3.0	-	
18.	Jamrozik (84)	Australia	Population sample		65-83	M	12203				
19.	MASS study (85)	UK	Multicenter GP		65-74	M	27147	4.9			
20.	Vazquez (86)	Belgium		41	65 and 75	M	727	4.5			

GP= General practice; HO= Health organization.

Risk factors for AAA

The risk factors for AAA found in the present study: age, male gender, smoking, low HDL cholesterol levels and drug-treated hypertension are the same as reported in other large studies as discussed in more detail in paper IV.

As discussed briefly in the introduction, atherosclerosis may induce AAA formation by causing mechanical weakening of the aortic wall. On the other hand, the altered vessel wall in AAA may also enhance the atherosclerotic process. To settle this issue and determine causal inferences, new prospective studies should be conducted. Our data indicate that the risk factors for atherosclerosis and AAA overlap, although there are some differences, such as the role of total serum cholesterol, which seems to be a weaker, and smoking, a stronger risk factor for AAA, as compared to myocardial infarction.

Ultrasound follow-up and growth rate of AAA

In the follow up study (Paper V), the mean growth rate of AAA was 1.82 mm/year, greater in women (2.43 mm/year) than in men (1.65 mm/year). The initial diameter of AAA and sex were the only independent factors being significantly associated with AAA growth. Review of literature (87) shows similar AAA growth rates in men, indicating a need of surveillance once a year or less frequently for AAAs with maximal diameter less than 40 mm (as the upper 95 % confidence interval for the yearly growth in our study was less than 4 mm), and once a year or more frequently for AAAs with maximal diameter 40 mm or greater, especially in women.

Ethical considerations

Risks, benefits and consequences of ultrasound screening

In every screening survey, the risks and cost of ultrasound screening are applied to the majority, and the benefits only to a few. Use of diagnostic ultrasound is not related to any reported adverse effects (88). Although many screening surveys for AAA are published during the last 20 years, only a few non-randomized studies have discussed the topic of benefits from screening. A non-randomized study of men with AAA from the UK (89) showed that screening was associated with reduced AAA-related mortality in men aged 65-73. Another non-randomized study (90) reported reduced rupture risk of AAA in a screened population.

The results from several ongoing randomized screening studies of AAA in men are being reported now. Four studies have reported up to a 5 year follow-up (43,80,91-92) and two of these without any statistically beneficial effects of screening. However, all 4 studies showed a reduction in AAA-related deaths in the screened population. Only one randomized study (93) has reported a 10 year follow-up, with a 21 percent reduction of AAA-related deaths in the ultrasound screened group of men as compared to the randomized non-screened group. The UK small aneurysm trial and American veterans (ADAM) study have shown that elective repair of asymptomatic AAA smaller than 5.5 cm does not improve survival (94,95) and therefore, elective repair is recommended when AAAs are 5.5 cm or larger in diameter.

Screening reveals many small abdominal aortic aneurysms. Most of these will never rupture or need surgical repair but may cause needless worry and risks from unnecessary procedures. Other possible adverse effects include depression due to false-positive results (96) and increased anxiety (97,98). These patients with small AAAs undergo periodic surveillance with ultrasound or CT imaging. Periodic ultrasound surveillance once a year or more frequently (especially in women) is recommended for AAA 4.0-5.4 cm (99-102), and intervals of 2-3 years are recommended for smaller AAAs (103,104). No studies have yet found any beneficial effect of drug treatment to reduce the expansion rate of AAA.

Conclusions and recommendations

The present study has shown that

- ultrasound is reliable and easily applicable diagnostic tools both for screening and surveillance of AAA.
- the variability in measurement with CT was similar to that found for ultrasound and both methods have clinically acceptable measurement error.
- the diameter as assessed by ultrasound and CT was similar, but compared to CT measurements, ultrasound slightly underestimates the diameter in non-aneurysmal aortas and tends to overestimate the diameter in aneurysmal aortas
- CT imaging is a reliable diagnostic tool with better resolution than ultrasound and great possibilities of multi-planar reconstructions and CT angiography, but with radiation hazard. Therefore, the use of CT should be as a pre-operative assessment tool and supplement to ultrasound.

- the ultrasound measured maximal infrarenal aortic diameter increases with age in both sexes.
- AAA is a disease of elderly men, the prevalence among men being fourfold that of women.
- age, smoking, drug-treated hypertension, and low levels of serum HDL cholesterol are significant risk factors for AAA
- the growth of an AAA is dependent on the initial diameter and gender, women having higher growth rate. The present study is thus adding evidence to the published literature review, showing that surveillance intervals of AAAs less than 4 cm in diameter should be no more than once a year or even less frequent. Those AAAs measuring 4 cm or greater, the surveillance intervals should be at least once a year, especially in women.

Future challenges

The scope of future prospective studies based on these data, observational as well as interventional, is to improve preventive and therapeutic guidelines.

An observational design with repeated ultrasound measurements makes it possible to examine the predictors of long-term prognosis of AAA, including sex differences. The fifth Tromsø study conducted in 2001 is an example of such studies. The present study shows that AAA is fourfold that prevalent in men as compared to women. Risk factors for AAA seem to be similar in both sexes: age, smoking, hypertension and low serum HDL cholesterol levels. However, the strong inverse relationship of serum HDL cholesterol and AAA needs to be further substantiated. Furthermore, the age-dependent increase in ultrasound measured maximal infrarenal aortic diameter and its predictors need to be confirmed in new studies.

An interventional study should examine whether the lowering of blood pressure, using antihypertensive drugs, reduces the development and growth of AAA. Cross-sectional data shows that hypertension is related to AAA only in women, whereas the use of antihypertensive drugs is associated with AAA in both sexes. The explanation of this observed phenomenon should be delineated in controlled clinical trials.

Follow up studies could also contribute to establish preventive treatment guidelines by examining the effect of increased physical activity, smoking cessation and use of statins on AAA. The use of statins may increase serum HDL cholesterol levels (105,106), and hopefully

prevent or reduce the development and growth of AAA. New potent cholesterol lowering and HDL increasing drugs may have similar effect.

Finally, there is still a need for new reproducibility studies measuring AAA with ultrasound validated with multi-planar CT angiography, the latter expected to be more accurate.

In summary there is a need for

- basic research that may explain the differences in the prevalence of AAA in men and women.
- investigative clinical research that may explain why women undergo AAA repair less frequently than men, as well as establishing guidelines for prevention and the timing of intervention.
- further technological developments of endovascular aneurysm repair, including smaller sized stentgrafts, better adapted to the specific anatomic challenges in women.

References

1. Collin J, Araujo L, Walton J, Lindsell D. Oxford screening programme for abdominal aortic aneurysm in men aged 65 to 74 years. Lancet 1988; 2:613-5.

2. Dubost C, Allary M, Oeconomos N. Resection of an aneurysm of the abdominal aorta-reestablishment of the continuity by a preserved human arterial graft. Am arch surg 1952; 64:405-8.

3. Melton LJ, Bickerstaff LK, Hollier LH, van Peenen HJ, Lie JT, Pairolero PC, Cherry KJ, O'Fallon WM. Changing incidence of abdominal aortic aneurysms: a population-based study. Am J Epidemiol 1984; 120: 379-86.

4. Maniglia R, Gregory JE. Increasing incidence of arteriosclerotic aortic aneurysms-analysis of 6000 autopsies. Am Arch Pathol 1952; 54:298-305.

5. Bengtsson H, Sonesson B, Bergqvist D. Incidence and prevalence of abdominal aortic aneurysms, estimated by necropsy studies and population screening by ultrasound. Ann NY Acad Sci 1996; 800:1-24.

6. Holdsworth JD. Screening for abdominal aortic aneurysm in Northumberland. Brit J Surg 1994; 81:710-2.

7. Lindholt JS, Juul S, Henneberg EW, Fasting H. Is screening for abdominal aortic aneurysm acceptable to the population? Selection and recruitment to hospital-based mass screening for abdominal aortic aneurysm. J Public Health Med 1998; 20:211-7.

8. Lucarotti M, Shaw E, Poskitt K, Heather B. The Gloucestershire aneurysm screening programme: the first 2 years' experience. Eur J Vasc Surg 1993; 7:397-401.

9. O'Kelly TJ, Heather BP. General practice-based population screening for abdominal aortic aneurysms: a pilot study. Brit J Surg 1989; 76:479-80.

10. Smith FC, Grimshaw GM, Paterson IS, Shearman CP, Hamer JD. Ultrasonographic screening for abdominal aortic aneurysm in an urban community. Br J Surg 1993; 80:1406-9.

11. Simoni G, Gianotti A, Ardia A, Baiardi A, Galleano R, Civalleri D. Screening study of abdominal aortic aneurysm in a general population: lipid parameters. Cardiovasc Surg 1996; 4:445-8.

12. Akkersdijk GJM, Puylaert JBCM, de Vries AC. Abdominal aortic aneurysm as an incidental finding in abdominal ultrasonography. Br J Surg 1991; 78:1261-3.

13. Lederle FA, Johnson GR, Wilson SE, Chute EP, Littooy FN, Bandyk D, Krupski WC, Barone GW, Acher CW, Ballard DJ. Prevalence and associations of abdominal aortic aneurysm detected through screening. Ann Intern Med 1997; 126:441-9.

14. Alcorn HG, Wolfson SK, Sutton-Tyrell K, Kuller LH, O'Leary D. Risk factors for abdominal aortic aneurysms in older adults enrolled in the Cardiovascular Health Study. Arterioscl Throm Vasc 1996; 16: 963-70.

15. van der Vliet JA, Boll APM. Abdominal aortic aneurysm. Lancet 1997; 349:863-6.

16. Alexander JJ. The pathobiology of aortic aneurysms. J Surg Research 2004; 117:163-75.

17. Reed D, Reed C, Stemmermann G, Hayashi T. Are aortic aneurysms caused by atherosclerosis? Circulation 1992; 85:205-11.

18. Louwrens HD, Adamson J, Powell JT, Greenhalgh RM. Risk-factors for artherosclerosis in men with stenosing or aneurysmal disease of the abdominal-aorta. Int Angiol 1993; 12:21-4.

19. Shteinberg D, Halak M, Shapiro S, Kinarty A, Sobol E, Lahat N, Karmeli R. Abdominal aortic aneurysm and aortic occlusive disease: a comparison of risk factors and inflammatory response . Eur J Vasc Endovasc Surg 2000; 20:462-5.

20. Blanchard JF, Armenian HK, Friesen PP. Risk factors for abdominal aortic aneurysm: Results of a case-control study. Am J Epidemiol 2000; 151:575-83.

21. Alonso M, Caeiro S, Cachaldora J, Segura R. Infected abdominal aortic aneurysm: In situ replacement with cryopreserved arterial homograft. Journal of Cardiovascular Surgery 1997; 38:371-5.

22. Ong G, Thomas BJ, Mansfield AO, Davidson BR, Taylor-Robinson D. Detection and widespread distribution of Chlamydia pneumoniae in the vascular system and its possible implication. J Clin Pathol 1996; 49: 102-6.

23. Shor A, Phillips JI, Ong G, Thomas BJ, Taylor-Robinson D. Chlamydia pneumoniae in atheroma: consideration of criteria for causality. J Clin Pathol 1998; 51:812-7.

24. Muller BT, Wegener OR, Grabitz K, Pillny M, Thomas L, Sandmann W. Mycotic aneurysms of the thoracic and abdominal aorta and iliac arteries: Experience with anatomic and extra-anatomic repair in 33 cases. J Vasc Surg 2001; 33:106-13.

25. Bengtsson H, Sonsson B, Länne T, Nilsson P, Solvig J, Loren I, Bergqvist D. Prevalence of abdominal aortic aneurysm in the offspring of patients dying from aneurysm rupture. Br J Surg 1992; 79:1142-3.

26. Adams DCR, Tulloh BR, Galloway SW, Shaw E, Tulloh AJ, Poskitt KR. Familial abdominal aortic aneurysm - prevalence and implications for screening. Eur J Vasc Surg 1993; 7:709-12.

27. Kadoglou NP, Liapis CD. Matrix metalloproteinases: contribution to pathogenesis, diagnosis, surveillance and treatment of abdominal aortic aneurysms. Cur Med Res Opin 2004; 20:419-32.

28. Wanhainen A, Björck M, Boman K, Rutegard J, Bergqvist D. Influence of diagnostic criteria on the prevalence of abdominal aortic aneurysm. J Vasc Surg 2001; 34:229-35.

29. Johnston KW, Rutherford RB, Tilson MD, Shah DM, Hollier L, Stanley JC. Suggested standards for reporting on arterial aneurysms. J Vasc Surg 1991; 13:452-8.

30. Sterpetti AV, Schultz RD, Feldhaus RJ, Cheng SE, Peetz DJ. Factors influencing enlargement rate of small abdominal aortic aneurysms . J Surg Research 1987; 43:211-9.

31. McGregor JC, Pollock JG, Anton HC. Value of ultrasonography in diagnosis of abdominal aortic-aneurysm. Scot Med J 1975; 20:133-7.

32. Collin J. A proposal for the precise definition of abdominal aortic aneurysm. J Cardiovasc Surg 1990; 31:168-9.

33. Moher D, Cole CW, Hill GB. Definition and management of abdominal aortic aneurysms-results from a Canadian survey. Can J Surg 1994; 37:29-32.

34. Lederle FA, Simel DL. Does this patient have abdominal aortic aneurysm? JAMA 1999; 281:77-82.

35. Cabellon S, Moncrief CL, Pierre DR, Cavanaugh DG. Incidence of abdominal aortic aneurysms in patients with atheromatous arterial disease. Am J Surg 1983; 146:575-6.

36. Lee KR, Walls WJ, Martin NL, Temleton AW. Practical approach to diagnosis of abdominal aortic aneurysms. Surg 1975; 78:195-201.

37. Brewster DC, Darling RC, Raines JK, Sarno R, Odonell TF, Ezpeleta M, Athanasoulis C. Assessment of abdominal aortic aneurysm size. Circulation 1977; 56:164-9.

38. Thomas ML, Patel MP, Wright CH. The diagnosis and management of abdominal aortic aneurysms: a comparison of computed tomography, ultrasound and aortography. Aust Radiol 1981; 25:162-8.

39. Thomas P, Shaw J, Ashton H, Kay D, Scott R. Accuracy of ultrasound in a screening programme for abdominal aortic aneurysms. J Med Screen 1994; 1:3-6.

40. Pleumeekers HJCM, Hoes AW, Mulder PGH, van der Does E, Hofman A, Lameris JS, Grobbee DE. Differences in observer variability of ultrasound measurements of the proximal and distal abdominal aorta. J Med Screen 1998; 5:104-8.

41. Pleumeekers HJCM, Hoes AW, van der Does E, van Urk H, Hofman A, de Jong PTVM. Aneurysms of the abdominal aorta in older adults. The Rotterdam study. Am J Epidemiol 1995; 142:1291-9.

42. Lindholt JS, Vammen S, Juul S, Henneberg EW, Fasting H. The validity of ultrasonographic scanning as screening method for abdominal aortic aneurysm. Eur J Vasc Endovasc Surg 1999; 17: 472-5.

43. Ashton HA, Buxton MJ, Campbell HE et.al. Multicentre aneurysm screening study (MASS): cost effectiveness analysis of screening for abdominal aortic aneurysms based on four year results from randomised controlled trial. Brit Med J 2002; 325:1135-38.

44. Akkersdijk GJ, Puylaert JB, Coerkamp EG, de Vries AC. Accuracy of ultrasonographic measurement of infrarenal abdominal aortic aneurysm. Br.J.Surg. 1994; 81:376.

45. Ellis M, Powell JT, Greenhalgh RM. Limitations of ultrasonography in surveillance of small abdominal aortic aneurysms. Br J Surg 1991; 78:614-6.

46. Emerton ME, Shaw E, Poskitt K, Heather BP. Screening for abdominal aortic aneurysm: a single scan is enough. Brit J Surg 1994; 81:1112-3.

47. Gomes MN, Choyke PL. Pre-operative evaluation of abdominal aortic aneurysms: ultrasound or computed tomography? J Cardiovasc Surg 1987; 28:159-66.

48. Gomes MN, Hakkal HG, Schellinger D. Ultrasonography and CT scanning: a comparative study of abdominal aortic aneurysms. Computerized Tomography 1978; 2:99-110.

49. Grimshaw GM, Docker MF. Accurate screening for abdominal aortic aneurysm. Clin Phys Physiol Meas 1992; 13:135-8.

50. Jaakkola P, Hippeläinen M, Farin P, Rytkönen S, Kainulainen S, Partanen K. Interobserver variability in measuring the dimensions of the abdominal aorta: comparison of ultrasound and computed tomography. Eur J Vasc Endovasc Surg 1996; 12:230-7.

51. Itani Y, Watanabe S, Masuda Y, Hanamura K, Asakura K, Sone S, Sunami Y, Miyamoto T. Measurement of aortic diameters and detection of asymptomatic aortic aneurysms in a mass screening program using a mobile helical computed tomography unit. Heart and Vessels 2002; 16:42-5.

52. Lederle FA, Wilson SE, Johnson GR, Reinke DB, Littooy FN, Acher CW, Messina LM, Ballard DJ, Ansel HJ. Variability in measurement of abdominal aortic aneurysms. J Vasc Surg 1995; 21:945-52.

53. Schmidt MH, Mitchell J, Downey DB. Sonographic surveillance of abdominal aortic aneurysms: What is the smallest change in measured diameter that reliably reflects aneurysm growth? Can Assoc Radiol J 1999; 50:241-6.

54. Wilmink ABM, Forshaw M, Quick CRG, Hubbard CS, Day NE. Accuracy of serial screening for abdominal aortic aneurysms by ultrasound. J Med Screen 2002; 9:125-7.

55. Aarts NJM, Schurink GWH, Kool LJS, Bode PJ, van Baalen JM, Hermans J, van Bockel JH. Abdominal aortic aneurysm measurement for endovascular repair: Intra- and interobserver variability of CT measurements. Eur J Vasc Endovasc Surg 1999; 18:475-80.

56. Horejs D, Gilbert PM, Burstein S, Vogezang RL. Normal aortoiliac diameters by CT. J Comput Assist Tomo 1988; 12:602-3.

57. Rubin GD, Paik DS, Johnston PC, Napel S. Measurement of the aorta and its branches with helical CT. Radiology 1998; 206:823-9.

58. Walter F, Henrot P, Blum A, Hirsch JJ, Beot S, Guillemin F, Boccaccini H, Regent D. Comparative value of MR-angiography, helical-CT and angiography in pre-operative assessment of abdominal aortic aneurysm. J Radiol 1998; 79:529-39.

59. Wanhainen A, Bergqvist D, Bjorck M. Measuring the abdominal aorta with ultrasonography and computed tomography - Difference and variability. Eur J Vasc Endovasc Surg 2002; 24:428-34.

60. Sprouse LR, Meier GH, Parent FN, DeMasi RJ, Glickman MH, Barber GA. Is ultrasound more accurate than axial computed tomography for determination of maximal abdominal aortic aneurysm diameter? Eur J Vasc Endovasc Surg 2004; 28:28-35.

61. Huber TS, Wang JG, Derrow AE, Dame DA, Ozaki CK, Zelenock GB, Flynn TC, Seeger JM. Experience in the United States with intact abdominal aortic aneurysm repair . J Vasc Surg 2001; 33:304-10.

62. Heller JA, Weinberg A, Arons A, Krishnasastry KV, Lyon RT, Deitch JS, Schulick AH, Bush HL, Kent KC. Two decades of abdominal aortic aneurysm repair: Have we made any progress? J Vasc Surg 2000; 32:1091-8.

63. Dardik A, Lin JW, Gordon TA. Results of elective abdominal aortic aneurysm repair in the 1990s: A population-based analysis of 2335 cases. J Vasc Surg 1999; 30:985-92.

64. Katz DJ, Stanley JC, Zelenock GB. Gender differences in abdominal aortic aneurysm prevalence, treatment, and outcome. J Vasc Surg 1997; 25:561-8.

65. Evans SM, Adam DJ, Bradbury AW. The influence of gender on outcome after ruptured abdominal aortic aneurysm. J Vasc Surg 2000; 32:258-62.

66. Parodi JC, Palmaz JC, Barone HD. Transfemoral intraluminal graft implantation for abdominal aortic aneurysms. Ann Vasc Surg 1991; 5:491-9.

67. Velazquez OC, Larson RA, Baum RA, Carpenter JP, Golden MA, Mitchell ME, Pyeron A, Barker CF, Fairman RM. Gender-related differences in infrarenal aortic aneurysm morphologic features: Issues relevant to Ancure and Talent endografts. J Vasc Surg 2001; 33:77-84.

68. Carpenter JP, Baum RA, Barker CF, Golden MA, Mitchell ME, Velazquez OC, Fairman RM. Impact of exclusion criteria on patient selection for endovascular abdominal aortic aneurysm repair. J Vasc Surg 2001; 34:1050-4.

69. Ouriel K, Greenberg RK, Clair DG, O'Hara PJ, Srivastava SD, Lyden SP, Sarac TP, Sampram E, Butler B. Endovascular aneurysm repair: Gender-specific results. J Vasc Surg 2003; 38:93-8.

70. Laheij RJF, van Marrewijk CJ, Buth J, Harris PL. The influence of team experience on outcomes of endovascular stenting of abdominal aortic aneurysms. Eur J Vasc Endovasc Surg 2002; 24:128-33.

71. Zarins CK, White RA, Moll FL, Crabtree T, Bloch DA, Hodgson KJ, Fillinger MF, Fogarty TJ. The AneuRx stent graft: Four-year results and worldwide experience 2000. J Vasc Surg 2001; 33:135-45.

72. Mathison M, Becker GJ, Katzen BT, Benenati JF, Zemel G, Powell A, Kovacs ME, Lima MM. The influence of female gender on the outcome of endovascular abdominal aortic aneurysm repair. J Vasc Intv Radiol 2001; 12:1047-51.

73. Rosvold Berntsen GK. The interpretation of forearm bone mineral density. The Tromsø study. Institute of Community Medicine, University of Tromsø, 2000.

74. Rothman KJ, Greenland S. Precision and validity in epidemiological studies. Modern epidemiology. Philadelphia, USA: Lippincott-Raven, 1998.

75. Criqui MH, Barretconnor E, Austin M. Differences between respondents and nonrespondents in a population-based cardiovascular study. Am J Epidemiol 1978; 108:367-72.

76. Holme I, Helgeland A, Hjermann I, Leren P, Lund-Larsen PG. Four and a 2/3 years incidence of coronary heart disease in middle-aged men- The Oslo study. Am J Epidemiol 1980; 112:149-60.

77. Wyller TB, Bautz-Holter E, Holmen J. Prevalence of stroke and stroke-related diability in North-Trøndelag County, Norway. Cerebrovasc Dis 1994; 4:421-7.

78. Mjøs OD. Lipid effects of smoking. Am Heart J 1988; 115:272-5.

79. Rosenthal TC, Siepel T, Zubler J, Horwitz M. The use of ultrasonography to scan the abdomen of patients presenting for routine physical examinations. J Fam Pract 1994; 38:380-5.

80. Scott RAP, Wilson NM, Ashton HA, Kay DN. Influence of screening on the incidence of ruptured abdominal aortic aneurysm: 5-year results of a randomized controlled study. Brit J Surg 1995; 82:1066-70.

81. Scott RAP, Tisi PV, Ashton HA, Allen DR. Abdominal aortic aneurysm rupture rates: a 7-year follow-up of the entire abdominal aortic aneurysm population detected by screening. J Vasc Surg 1998; 28:124-8.

82. Krohn CD, Kullmann G, Kvernbo K, Rosen L, Kroese A. Ultrasonographic screening for abdominal aortic aneurysm. Eur j Surg 1992; 158:527-30.

83. Morris GE, Hubbard CSF, Quick CRG. An abdominal aortic aneurysm screening program for all males over the age of 50 years. Eur J Vasc Surg 1994; 8:156-60.

84. Jamrozik K, Spencer CA, Lawrence-Brown MM, Norman PE. Does the Mediterranean paradox extend to abdominal aortic aneurysm? Int J Epidemiol 2001; 30:1071-5.

85. Ashton HA, Buxton MJ, Day NE et.al. The Multicentre Aneurysm Screening Study (MASS) into the effect of abdominal aortic aneurysm screening on mortality in men: a randomised controlled trial. Lancet 2002; 360:1531-9.

86. Vazquez C, Sakalihasan N, D'Harcour J, Limet R. Routine ultrasound screening for abdominal aortic aneurysm among 65- and 75-year-old men in a city of 200,000 inhabitants. Ann Vasc Surg 1998; 12:544-9.

87. Brady AR, Thompson SG, Fowkes FGR, Greenalgh RM, Powell J. Abdominal aortic aneurysm expansion - Risk factors and time intervals for surveillance. Circulation 2004; 110:16-21.

88. Barnett S, Gail R, Harr T, Ziskin M, Rott H, Duck F, Maeda K. International recommendations and guidelines for the safe use of diagnostic ultrasound in medicine. Ultrasound Med Biol 2000; 26:355-66.

89. Heather BP, Poskitt KR, Earnshaw JJ, Whyman M, Shaw E. Population screening reduces mortality rate from aortic aneurysm in men. Br J Surg 2000; 87:750-3.

90. Wilmink TBM, Quick CRG, Hubbard CS, Day NE. The influence of screening on the incidence of ruptured abdominal aortic aneurysms . J Vasc Surg 1999; 30:203-8.

91. Lindholt JS, Juul S, Fasting H, Henneberg EW. Hospital costs and benefits of screening for abdominal aortic aneurysms. Results from a randomised population screening trial. Eur J Vasc Endovasc Surg 2002; 23:55-60.

92. Norman PE, Jamrozik K, Lawrence-Brown M, Dickinson J. Western Australian randomized controlled trial of screening for abdominal aortic aneurysm. Br J Surg 2003; 90:492.

93. Vardulaki KA, Walker NM, Couto E, Day NE, Thompson SG, Ashton HA, Scott RAP. Late results concerning feasibility and compliance from a randomized trial of ultrasonographic screening for abdominal aortic aneurysm. Br J Surg 2002; 89:861-4.

94. Powell JT, Brady AR, Brown LC, Forbes JF, Fowkes FGR, Greenalgh RM, Ruckley CV, Thompson SG. Mortality results for randomised controlled trial of early elective surgery or ultrasonographic surveillance for small abdominal aortic aneurysms. Lancet 1998; 352:1649-55.

95. Lederle FA, Johnson GR, Wilson SE. Rupture rate of large abdominal aortic aneurysms in patients refusing or unfit for elective repair. J Am Med Assoc 2002; 287:2968-72.

96. Marteau TM. Psychological cost of screening. Brit Med J 1989; 299:527.

97. Stewart-Brown S, Farmer A. Screening could seriously damage your health - Decisions to screen must take account of the social and psychological costs. Brit Med J 1997; 314:533-4.

98. Lucarotti ME, Heather BP, Shaw E, Poskitt KR. Psychological morbidity associated with abdominal aortic aneurysm screening. Eur J Vasc Endovasc Surg 1997; 14:499-501.

99. Lederle FA, Johnson GR, Wilson SE, Acher CW, Ballard DJ, Littooy FN, Messina LM. Quality of life, impotence, and activity level in a randomized trial of immediate repair versus surveillance of small abdominal aortic aneurysm. J Vasc Surg 2003; 38:745-52.

100. Lederle FA. Ultrasonographic screening for abdominal aortic aneurysms. Ann Intern Med 2003; 139:516-22.

101. Lederle FA. Risk of rupture of large abdominal aortic aneurysms - Disagreement among vascular surgeons. Arch Intern Med 1996; 156:1007-9.

102. Vardulaki KA, Prevost TC, Walker NM, Day NE, Wilmink ABM, Quick CRG, Ashton HA, Scott RAP. Growth rates and risk of rupture of abdominal aortic aneurysms. Br J Surg 1998; 85:1674-80.

103. Santilli SM, Littooy FN, Cambria RA. Expansion rates and outcomes for the 3.0 cm to the 3.9 cm infrarenal abdominal aortic aneurysm. J Vasc Surg 2002; 35:666-71.

104. Grimshaw GM, Thompson JM, Hamer JD. Astatistical analysis of the growth of small abdominal aortic aneurysms. Eur J Vasc Surg 1994; 8:741-6.

105. Laws PE, Spark JI, Cowled PA, Fitridge RA. The role of statins in vascular disease. Eur J Vasc Endovasc Surg 2004; 27:6-16.

106. Powell JT, Brady AR. Detection, management, and prospects for the medical treatment of small abdominal aortic aneurysms. Arterioscl Throm Vasc Biol 2004; 24:241-5.

APPENDIX A

Information leaflet

Questionnaires,

Norwegian and English versions

Declarations of consent

Innbydelse til

HELSEUNDERSØKELSEN

Fødselsdato Personnr. Kommune Kretsnr.

Velkommen til helseundersøkelsen i Tromsø!

Helseundersøkelsen kommer nå til Tromsø. Tid og sted for frammøte finner du nedenfor. Du finner også en orientering om undersøkelsen i den vedlagte brosjyren.

Vi ber deg fylle ut spørreskjemaet på baksiden og ta det med til undersøkelsen.

Undersøkelsen blir mest verdifull om frammøtet blir så fullstendig som mulig. Vi håper derfor at du har mulighet til å komme. Møt selv om du kjenner deg frisk, om du er under legebehandling, eller om du har fått målt kolesterol og blodtrykk i den senere tid.

Vennlig hilsen

Kommunehelsetjenesten
Fagområdet medisin, Universitetet i Tromsø
Statens helseundersøkelser

EGEN HELSE

Hvordan er helsen din nå? *Sett bare ett kryss.*

Dårlig	12	1
Ikke helt god		2
God		3
Svært god		4

Har du, eller har du hatt:

	JA	NEI	Alder første gang
Hjerteinfarkt 13			år
Angina pectoris (hjertekrampe) 16			år
Hjerneslag/hjerneblødning 19			år
Astma 22			år
Diabetes (sukkersyke) 25			år

Bruker du medisin mot høyt blodtrykk?

Nå	28	1
Før, men ikke nå		2
Aldri brukt		3

Har du i løpet av det siste året vært plaget med smerter og/eller stivhet i muskler og ledd som har vært i minst 3 måneder sammenhengende? 29 JA NEI

Har du de siste to ukene følt deg:

	Nei	Litt	En god del	Svært mye
Nervøs og urolig? 30				
Plaget av angst? 31				
Trygg og rolig? 32				
Irritabel? 33				
Glad og optimistisk? 34				
Nedfor/deprimert? 35				
Ensom? 36				
	1	2	3	4

RØYKING

Røykte noen av de voksne hjemme da du vokste opp? 37 JA NEI

Bor du, eller har du bodd, sammen med noen dagligrøykere etter at du fylte 20 år? 38 JA NEI

Hvis "JA", hvor mange år tilsammen? 39 Antall år

Hvor lenge er du vanligvis daglig tilstede i røykfylt rom? 41 Antall timer

Sett 0 hvis du ikke oppholder deg i røykfylt rom.

Røyker du selv:

	JA	NEI
Sigaretter daglig? 43		
Sigarer/sigarillos daglig? 44		
Pipe daglig? 45		

Hvis du har røykt daglig tidligere, hvor lenge er det siden du sluttet? 46 Antall år

Hvis du røyker daglig nå eller har røykt tidligere:

Hvor mange sigaretter røyker eller røykte du vanligvis daglig? 48 Antall sigaretter

Hvor gammel var du da du begynte å røyke daglig? 52 Alder år

Hvor mange år tilsammen har du røykt daglig? 54 Antall år

MOSJON

Hvordan har din fysiske aktivitet i fritiden vært det siste året? *Tenk deg et ukentlig gjennomsnitt for året.*
Arbeidsvei regnes som fritid.

	Timer pr. uke: Ingen	Under 1	1-2	3 og mer
Lett aktivitet *(ikke svett/andpusten)* 56				
Hard fysisk aktivitet *(svett/andpusten)* 57				
	1	2	3	4

KAFFE

Hvor mange kopper kaffe drikker du daglig?
Sett 0 hvis du ikke drikker kaffe daglig.

		Antall kopper
Kokekaffe	58	
Annen kaffe	60	

ALKOHOL

Er du total avholdsmann/-kvinne? 62 JA NEI

Hvor mange ganger i måneden drikker du vanligvis alkohol? *Regn ikke med lettøl.*
Sett 0 hvis mindre enn 1 gang i mnd. 63 Antall ganger

Hvor mange glass øl, vin eller brennevin drikker du vanligvis i løpet av to uker? 65
Regn ikke med lettøl.
Sett 0 hvis du ikke drikker alkohol.

Øl	Vin	Brennevin
glass	glass	glass

Hva slags margarin eller smør bruker du vanligvis på brødet? *Sett ett kryss.*

Bruker ikke smør/margarin	71	1
Meierismør		2
Hard margarin		3
Blot (soft) margarin		4
Smør/margarin blanding		5
Lettmargarin		6

UTDANNING

Hvilken utdanning er den høyeste du har fullført?

Grunnskole, 7-10 år, framhaldsskole, folkehøgskole	72	1
Realskole, middelskole, yrkesskole, 1-2-årig videregående skole		2
Artium, ok.gymnas, allmennfaglig retning i videregående skole		3
Høgskole/universitet, mindre enn 4 år		4
Høgskole/universitet, 4 år eller mer		5

Hva slags arbeidssituasjon har du nå?

Lønnet arbeid	73	
Heltids husarbeid	74	
Utdanning, militærtjeneste	75	
Arbeidsledig, permittert	76	

Hvor mange timer lønnet arbeid har du i uka? 77 Antall timer

Mottar du nå noen av følgende ytelser?

Sykepenger (sykmeldt)	79	
Attføring	80	
Uførepensjon	81	
Alderspensjon	82	
Sosialstøtte	83	
Arbeidsløshetstrygd	84	

M M

Har en eller flere av foreldre eller søsken hatt hjerteinfarkt (sår på hjertet) eller angina pectoris (hjertekrampe)? 85

JA	NEI	VET IKKE

English translation of invitation with the first questionnaire used in the health survey in Tromsø 1994/95

Translation based on translations by Kevin McCafferty and Anne Clancy

HEALTH SURVEY
INVITATION

"This is your chance"

Date of birth Social security No.

Municipality Electoral ward No.

Welcome to the Tromsø Health Survey!

The Health Survey is coming to Tromsø. This leaflet will tell you when and where. You will also find information about the survey in the enclosed brochure.

We would like you to fill in the form overleaf and take it with you to the examination.

The more people take part in the survey, the more valuable its results will be. We hope, therefore, that you will be able to come. Come along even if you feel healthy, if you are currently receiving medical treatment, or if you have had your cholesterol and blood pressure levels taken recently.

Yours sincerely,
Municipal Health Authorities
Faculty of Medicine - University of Tromsø
National Health Screening Service

"This is a real opportunity — Take it!"

Your own health

What is your current state of health?
Tick one box only.

Poor	☐
Not so good	☐
Good	☐
Very good	☐

Do you have, or have you ever had:

	YES	NO	Age first time
Myocardial infarction	☐	☐	_____ years
Angina pectoris	☐	☐	_____ years
Stroke/ brain haemorrhage	☐	☐	_____ years
Asthma	☐	☐	_____ years
Diabetes	☐	☐	_____ years

Do you take medicine for high blood pressure?

At the moment	☐
Used to, but not any longer	☐
Never have	☐

Have you during the last year suffered from pains and/or stiffness in muscles and joints that have lasted continuously for at least 3 months?

YES ☐ NO ☐

Have you in the last two weeks felt:

	No	A little	A lot	Very much
Nervous or worried?	☐	☐	☐	☐
Anxious?	☐	☐	☐	☐
Secure and calm?	☐	☐	☐	☐
Irritable?	☐	☐	☐	☐
Happy and optimistic?	☐	☐	☐	☐
Down/depressed?	☐	☐	☐	☐
Lonely?	☐	☐	☐	☐

Smoking

Did any of the adults at home smoke while you were growing up? YES ☐ NO ☐

Do you now, or have you previously, lived with daily smokers after your 20th birthday?

YES ☐ NO ☐

If "YES", for how many years in all? ____Years

How many hours a day do you normally spend in smoke-filled rooms? _____Hours
Put 0 if you do not spend time in smoke-filled rooms.

Do you yourself smoke:	YES	NO
Cigarettes daily?	☐	☐
Cigars/cigarillos daily?	☐	☐
Pipe daily ?	☐	☐

If you previously smoked daily, how long is it since you stopped? _____ Years

If you smoke daily at the moment, or have smoked before:

How many cigarettes do you smoke/did you smoke per day? _____ Cigarettes

How old were you when you began smoking daily? Age _____ Years

How many years in all have you smoked daily? _____ Years

Exercise

How has your physical activity in leisure time been during this last year? *Think of your weekly average for the year. Time spent going to work counts as leisure time.*

	Hours pr. week None	Less than 1	1-2	3 or more
Light activity (*not sweating or out of breath*)	☐	☐	☐	☐
Hard activity (*sweating/ out of breath*)	☐	☐	☐	☐

Coffee

How many cups of coffee do you drink daily? *Put 0 if you do not drink coffee daily.* Cups

Boiled coffee (i.e., grind boiled and allowed to draw) ☐☐☐

Other coffee ☐☐☐

Alcohol

Are you a teetotaler? YES ☐ NO ☐

How many times a month do you normally drink alcohol? *Do not count low-alcohol beer. Put 0 if less than once a month.* ____ Times

How many glasses of beer, wine or spirits do you normally drink in a fortnight? *Do not count low-alcohol beer. Put 0 if less than once a month.*

Beer Glasses	Wine Glasses	Spirits Glasses
☐☐	☐☐	☐☐

Fat

What kind of margarine or butter do you normally use on bread? *Tick one box only.*

Don't use butter/margarine	☐
Creamery butter	☐
Hard margarine	☐
Soft margarine	☐
Butter/margarine blend	☐
Light margarine	☐

Education/work

What is the highest level of education you have completed?

7-10 years primary/secondary school, modern secondary school, folk high school	☐
Technical school, middle school, vocational.. school, 1-2 years' senior high school	☐
A-levels/High school diploma, (3-4 years)	☐
College/university, less than 4 years	☐
College/university, 4 or more years	☐

What is your current work situation?

Paid work	☐
Full-time housework	☐
Education, military service	☐
Unemployed, redundant	☐

How many hours of paid work do you have pr. week? _____ Hours

Do you receive any of the following benefits?

Sickness benefit (sick leave)	☐
Rehabilitation benefit	☐
Disability pension	☐
Old-age pension	☐
Social welfare benefits	☐
Unemployment benefit	☐

Illness in the family

Have one or more of your parents or siblings had a heart attack or had angina (heart cramp)?

YES	NO	DON'T KNOW
☐	☐	☐

SAMTYKKEERKLÆRING

I invitasjonsbrosjyren til Helseundersøkelsen i Tromsø 1994-95, er jeg orientert om undersøkelsens formål. Jeg er kjent med at opplysningene blir behandlet strengt fortrolig og at undersøkelsen er godkjent av Datatilsynet og forelagt den forskningsetiske komité for Nord-Norge. Jeg er kjent med at jeg senere kan reservere meg mot bruk av opplysninger om meg.

Jeg samtykker i:

1. at melding om mine resultater sendes til min faste lege.
2. at blodproven oppbevares til senere medisinsk forskning.
3. at mine resultater kan brukes til medisinsk forskning, eventuelt ved å sammenholde opplysningene om meg med opplysninger fra andre helse- og sykdomsregister (f.eks. kreftregister og dødsårsaksregister) og mine data fra de tidligere helseundersøkelsene i Tromsø.

Vennligst stryk det/de avsnitt du reserverer deg mot.

Tromsø, ...

Underskrift

SPESIALUNDERSØKELSEN '94-95

SAMTYKKE-ERKLÆRING

I invitasjonsbrosjyren til Spesialundersøkelsen i Tromsø 1994-95 er jeg orientert om undersøkelsens formål. Jeg vet at opplysningene blir behandlet strengt fortrolig og at undersøkelsen er godkjent av Datatilsynet og anbefalt av den regionale komite for medisinsk forskningsetikk. Jeg vet at jeg senere kan reservere meg mot bruk av opplysninger om meg.

Vennligst kryss av for det/de avsnitt du reserverer deg mot.

Jeg samtykker i:

☐ at melding om mine resultater sendes til min lege eller Regionsykehuset i Tromsø dersom jeg trenger videre undersøkelse eller behandling.

☐ at mine resultater kan brukes til medisinsk forskning, ved å sammenholde opplysningene med andre helse- og sykdomsregistre og opplysninger fra de tidligere helseundersøkelser i Tromsø.

☐ at blodprøven kan oppbevares og brukes til medisinsk forskning.

☐ at Helseundersøkelsen i Tromsø kan kontakte meg senere med forespørsel om å delta i undersøkelser.

Tromsø, ...

Dato Underskrift

Helseundersøkelsen i Tromsø

Hovedformålet med Tromsøundersøkelsene er å skaffe ny kunnskap om hjerte-karsykdommer for å kunne forebygge dem. I tillegg skal undersøkelsen øke kunnskapen om kreftsykdommer og andre alminnelige plager som f.eks. allergier, smerter i muskulatur og nervøse lidelser. Vi ber deg derfor svare på noen spørsmål om forhold som kan ha betydning for risikoen for disse og andre sykdommer.

Skjemaet er en del av Helseundersøkelsen som er godkjent av Datatilsynet og av Regional komite for medisinsk forskningsetikk. Svarene brukes bare til forskning og behandles strengt fortrolig. Opplysningene kan senere bli sammenholdt med informasjon fra andre offentlige helseregistre etter de regler som Datatilsynet og Regional komite for medisinsk forskningsetikk gir.

Hvis du er i tvil om hva du skal svare, sett kryss i den ruten som du synes passer best.

Det utfylte skjema sendes i vedlagte svarkonvolutt. Portoen er betalt.

På forhånd takk for hjelpen!

Med vennlig hilsen

Fagområdet medisin
Universitetet i Tromsø **Statens helseundersøkelser**

Hvis du ikke ønsker å besvare spørreskjemaet, sett kryss i ruten under og returner skjemaet. Da slipper du purring.

Jeg ønsker ikke å besvare spørreskjemaet ..... 17 ☐

Dag Mnd År

Dato for utfylling av skjema: ..... 18 ...../...../.....

OPPVEKST

I hvilken kommune bodde du da du fylte 1 år?

..... 24 - 28

Hvis du ikke bodde i Norge, oppgi land i stedet for kommune.

Hvordan var de økonomiske forhold i familien under din oppvekst?
- Meget gode ..... 29 ☐
- Gode ..... ☐
- Vanskelige ..... ☐
- Meget vanskelige ..... ☐

Hvor mange av de første 3 årene av ditt liv
- bodde du i by? ..... 30 _____ år
- hadde dere katt eller hund i hjemmet? ..... 31 _____ år

Hvor mange av de første 15 årene av ditt liv
- bodde du i by? ..... 32 _____ år
- hadde dere katt eller hund i hjemmet? ..... 34 _____ år

BOLIG

Hvem bor du sammen med?

Sett ett kryss for hvert spørsmål og angi antall.	Ja	Nei	Antall
Ektefelle/samboer 36	☐	☐	
Andre personer over 18 år 37	☐	☐	_____
Personer under 18 år 40	☐	☐	_____

Hvor mange av barna har plass i barnehage? ..... 43 _____

Hvilken type bolig bor du i?
- Enebolig/villa ..... 45 ☐ 1
- Gårdsbruk ..... ☐ 2
- Blokk/terrasseleilighet ..... ☐ 3
- Rekkehus/2-4 mannsbolig ..... ☐ 4
- Annen bolig ..... ☐ 5

Hvor stor er din boenhet? ..... 46 _____ m²

I omtrent hvilket år ble boligen bygget? ..... 49 _____

	Ja	Nei
Er boligen isolert etter 1970? 53	☐	☐
Bor du i underetasje/kjeller? 54	☐	☐
Hvis "Ja", er gulvbelegget lagt på betong? 55	☐	☐

Hvordan er boligen hovedsakelig oppvarmet?
- Elektrisk oppvarming ..... 56 ☐
- Vedfyring ..... ☐
- Sentralvarmeanlegg oppvarmet med:
  - Parafin ..... ☐
  - Elektrisitet ..... ☐

	Ja	Nei
Er det heldekkende tepper i stua? 60	☐	☐
Er det katt i boligen? 61	☐	☐
Er det hund i boligen? 62	☐	☐

ARBEID

Hvis du er i lønnet eller ulønnet arbeid, hvordan vil du beskrive ditt arbeid?
- For det meste stillesittende arbeid? ..... 63 ☐ 1
  (f.eks. skrivebordsarbeid, montering)
- Arbeid som krever at du går mye? ..... ☐ 2
  (f.eks. ekspeditorarb., lett industriarb., undervisning)
- Arbeid hvor du går og løfter mye? ..... ☐ 3
  (f.eks. postbud, pleier, bygningsarbeid)
- Tungt kroppsarbeid? ..... ☐ 4
  (f.eks. skogsarb., tungt jordbruksarb., tungt bygn.arb.)

Kan du selv bestemme hvordan arbeidet ditt skal legges opp?
- Nei, ikke i det hele tatt ..... 64 ☐ 1
- I liten grad ..... ☐ 2
- Ja, i stor grad ..... ☐ 3
- Ja, det bestemmer jeg selv ..... ☐ 4

	Ja	Nei
Har du skiftarbeid, nattarbeid eller går vakter? 65	☐	☐

Har du noen av følgende yrker (heltid eller deltid)?

Sett ett kryss for hvert spørsmål.	Ja	Nei
Sjåfør 66	☐	☐
Bonde/gårdbruker	☐	☐
Fisker	☐	☐

EGNE SYKDOMMER

Har du noen gang hatt.
Sett ett kryss for hvert spørsmål. Oppgi alderen ved hendelsen.
*Hvis det har skjedd flere ganger, hvor gammel var du **siste** gang?*

	Ja	Nei	Alder
Lårhalsbrudd 69	☐	☐	_____
Brudd ved håndledd/underarm 72	☐	☐	_____
Nakkesleng (whiplash) 75	☐	☐	_____
Skade som førte til sykehusinnleggelse 78	☐	☐	_____
Sår på magesekken 81	☐	☐	_____
Sår på tolvfingertarmen 84	☐	☐	_____
Magesår-operasjon 87	☐	☐	_____
Operasjon på halsen 90	☐	☐	_____

Har du eller har du hatt:
Sett ett kryss for hvert spørsmål.

	Ja	Nei
Kreftsykdom 93	☐	☐
Epilepsi (fallesyke)	☐	☐
Migrene	☐	☐
Kronisk bronkitt	☐	☐
Psoriasis	☐	☐
Benskjørhet (osteoporose) 98	☐	☐
Fibromyalgi/fibrositt/kronisk smertesyndrom	☐	☐
Psykiske plager som du har søkt hjelp for	☐	☐
Stoffskiftesykdom (skjoldbruskkjertel)	☐	☐
Sykdom i leveren	☐	☐
Nyrestein 103	☐	☐
Blindtarmsoperasjon	☐	☐
Allergi og overfølsomhet		
Atopisk eksem (f.eks. barneeksem)	☐	☐
Håndeksem	☐	☐
Høysnue	☐	☐
Matvareallergi 108	☐	☐
Annen overfølsomhet (ikke allergi)	☐	☐

Hvor mange ganger har du hatt forkjølelse, influensa, "ræksjuka" og lignende siste halvår? 110 ____ ganger

	Ja	Nei
Har du hatt dette siste 14 dager? 112	☐	☐

SYKDOM I FAMILIEN

Kryss av for de slektningene som har eller har hatt noen av sykdommene:
Kryss av for "Ingen" hvis ingen av slektningene har hatt sykdommen.

	Mor	Far	Bror	Søster	Barn	Ingen
Hjerneslag eller hjerneblødning 113	☐	☐	☐	☐	☐	☐
Hjerteinfarkt før 60 års alder 119	☐	☐	☐	☐	☐	☐
Kreftsykdom 125	☐	☐	☐	☐	☐	☐
Astma 131	☐	☐	☐	☐	☐	☐
Mage/tolvfingertarm-sår 137	☐	☐	☐	☐	☐	☐
Benskjørhet (osteoporose) 143	☐	☐	☐	☐	☐	☐
Psykiske plager 149	☐	☐	☐	☐	☐	☐
Allergi 155	☐	☐	☐	☐	☐	☐
Diabetes (sukkersyke) 161	☐	☐	☐	☐	☐	☐
– alder da de fikk diabetes 167	____	____	____	____	____	

SYMPTOMER

	Ja	Nei
Hoster du omtrent daglig i perioder av året? 174	☐	☐
Hvis "Ja":		
Er hosten vanligvis ledsaget av oppspytt? 176	☐	☐
Har du hatt slik hoste så lenge som i en 3 måneders periode i begge de to siste år? 179	☐	☐
Har du hatt episoder med piping i brystet? 180	☐	☐
Hvis "Ja", har dette oppstått:		
Sett ett kryss for hvert spørsmål.		
Om natten 181	☐	☐
Ved luftveisinfeksjoner	☐	☐
Ved fysiske anstrengelser	☐	☐
Ved sterk kulde	☐	☐
Har du merket anfall med plutselig endring i pulsen eller hjerterytmen siste år? 185	☐	☐

Hvor ofte er du plaget av søvnløshet?

Aldri, eller noen få ganger i året 186	☐ 1
1-2 ganger i måneden	☐ 2
Omtrent en gang i uken	☐ 3
Mer enn en gang i uken	☐ 4

Hvis du er plaget av søvnløshet i perioder, når på året er du mest plaget?

Ingen spesiell tid 187	☐ 1
Særlig i mørketiden	☐ 2
Særlig i midnattsoltiden	☐ 3
Særlig vår og høst	☐ 4

	Ja	Nei
Har du det siste året vært plaget av søvnløshet slik at det har gått ut over arbeidsevnen? 188	☐	☐

Hvor ofte er du plaget av hodepine?

Sjelden eller aldri 189	☐ 1
En eller flere ganger i måneden	☐ 2
En eller flere ganger i uken	☐ 3
Daglig	☐ 4

Hender det at tanken på å få alvorlig sykdom bekymrer deg?

Ikke i det hele tatt 190	☐ 1
Bare i liten grad	☐ 2
En del	☐ 3
Ganske mye	☐ 4

BRUK AV HELSEVESENET

Hvor mange ganger har du siste året, på grunn av egen helse eller sykdom, vært:
*Sett **0** hvis du **ikke** har hatt slik kontakt.*

	Antall ganger siste år
Hos vanlig lege/legevakt 191	_____
Hos psykolog eller psykiater	_____
Hos annen legespesialist utenfor sykehus	_____
På poliklinikk 197	_____
Innlagt i sykehus	_____
Hos bedriftslege	_____
Hos fysioterapeut 203	_____
Hos kiropraktor	_____
Hos akupunktør	_____
Hos tannlege 209	_____
Hos naturmedisiner (homøopat, soneterapeut o.l.)	_____
Hos håndspålegger, synsk eller "leser"	_____

LEGEMIDLER OG KOSTTILSKUDD

Har du det siste året periodevis brukt noen av de følgende midler daglig eller nesten daglig?
Angi hvor mange måneder du brukte dem.
*Sett **0** hvis du **ikke** har brukt midlene.*

Legemidler
- Smertestillende ..... 215 ____ mnd.
- Sovemedisin ..... ____ mnd.
- Beroligende midler ..... ____ mnd.
- Medisin mot depresjon ..... 231 ____ mnd.
- Allergimedisin ..... ____ mnd.
- Astmamedisin ..... ____ mnd.

Kosttilskudd
- Jerntabletter ..... 227 ____ mnd.
- Kalktabletter eller benmel ..... ____ mnd.
- Vitamin D-tilskudd ..... ____ mnd.
- Andre vitamintilskudd ..... 233 ____ mnd.
- Tran eller fiskeoljekapsler ..... ____ mnd.

Har du de siste 14 dager brukt følgende legemidler eller kosttilskudd?
*Sett **ett** kryss for **hvert** spørsmål.*

	Ja	Nei
Legemidler		
Smertestillende medisin 237	☐	☐
Febersenkende medisin	☐	☐
Migrenemedisin	☐	☐
Eksemsalve	☐	☐
Hjertemedisin (ikke blodtrykksmedisin)	☐	☐
Kolesterolsenkende medisin 242	☐	☐
Sovemedisin	☐	☐
Beroligende medisin	☐	☐
Medisin mot depresjon	☐	☐
Annen nervemedisin	☐	☐
Syrenøytraliserende midler 247	☐	☐
Magesårsmedisin	☐	☐
Insulin	☐	☐
Tabletter mot diabetes (sukkersyke)	☐	☐
Tabletter mot lavt stoffskifte (thyroxin)	☐	☐
Kortisontabletter 252	☐	☐
Annen medisin	☐	☐
Kosttilskudd		
Jerntabletter	☐	☐
Kalktabletter eller benmel	☐	☐
Vitamin D-tilskudd	☐	☐
Andre vitamintilskudd 257	☐	☐
Tran eller fiskeoljekapsler	☐	☐

VENNER

Hvor mange gode venner har du som du kan snakke fortrolig med og gi deg hjelp når du trenger det? ... 259 ____ gode venner
Tell ikke med de du bor sammen med, men ta med andre slektninger!

Hvor mange av disse gode vennene har du kontakt med minst en gang i måneden? ..... 261 ____

	Ja	Nei
Føler du at du har nok gode venner? 263	☐	☐

Hvor ofte tar du vanligvis del i foreningsvirksomhet som f.eks. syklubb, idrettslag, politiske lag, religiøse eller andre foreninger?
- Aldri, eller noen få ganger i året ..... 264 ☐ 1
- 1-2 ganger i måneden ..... ☐ 2
- Omtrent en gang i uken ..... ☐ 3
- Mer enn en gang i uken ..... ☐ 4

KOSTVANER

Hvis du bruker smør eller margarin på brødet, hvor mange skiver rekker en liten porsjonspakning vanligvis til? Vi tenker på slik porsjonspakning som du får på fly, på kafé o.l. (10-12 gram).

Den rekker til omtrent ..... 265 _____ skiver

Hva slags fett blir vanligvis brukt til **matlaging** (ikke på brødet) i din husholdning?
- Meierismør ..... 266 ☐
- Hard margarin ..... ☐
- Bløt (Soft) margarin ..... ☐
- Smør/margarin blanding ..... ☐
- Oljer ..... 270 ☐

Hva slags type brød (kjøpt eller hjemmebakt) spiser du vanligvis?
Sett ett eller to kryss!

	Loff	Fint brød	Kneip-brød	Grov-brød	Knekke-brød
Brødtypen ligner mest på:	☐ 271	☐	☐	☐	☐ 275

Hvor mye (i **antall** glass, kopper, poteter eller brødskiver) spiser eller drikker du vanligvis **daglig** av følgende matvarer?
*Kryss av for **alle** matvarene.*

	0	Færre enn 1	1-2	3-4	5-6	Mer enn 6
Helmelk (søt eller sur) (glass) ... 276	☐	☐	☐	☐	☐	☐
Lettmelk (søt eller sur) (glass) ...	☐	☐	☐	☐	☐	☐
Skummet melk (søt eller sur) (glass) ...	☐	☐	☐	☐	☐	☐
Te (kopper) ...	☐	☐	☐	☐	☐	☐
Appelsinjuice (glass) ...	☐	☐	☐	☐	☐	☐
Poteter ... 281	☐	☐	☐	☐	☐	☐
Brødskiver totalt (inkl. knekkebrød) ...	☐	☐	☐	☐	☐	☐
Brødskiver med						
– fiskepålegg (f.eks. makrell i tomat) ...	☐	☐	☐	☐	☐	☐
– magert kjøttpålegg (f.eks. skinke) ...	☐	☐	☐	☐	☐	☐
– fetere kjøttpålegg (f.eks. salami) ...	☐	☐	☐	☐	☐	☐
– gulost ... 286	☐	☐	☐	☐	☐	☐
– brunost ...	☐	☐	☐	☐	☐	☐
– kaviar ...	☐	☐	☐	☐	☐	☐
– syltetøy og annet søtt pålegg ...	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6

Hvor mange **ganger i uka** spiser du vanligvis følgende matvarer?
*Kryss av for **alle** matvarene.*

	Aldri	Færre enn 1	1	2-3	4-5	Omtrent daglig
Yoghurt ... 290	☐	☐	☐	☐	☐	☐
Kokt eller stekt egg ...	☐	☐	☐	☐	☐	☐
Frokostblanding/havregryn o.l. ...	☐	☐	☐	☐	☐	☐
Middag med						
– rent kjøtt ...	☐	☐	☐	☐	☐	☐
– pølser/kjøttpudding/-kaker ...	☐	☐	☐	☐	☐	☐
– feit fisk (f.eks. laks/ørr) ... 295	☐	☐	☐	☐	☐	☐
– mager fisk (f.eks. torsk) ...	☐	☐	☐	☐	☐	☐
– fiskeboller/-pudding/-kaker ...	☐	☐	☐	☐	☐	☐
– grønnsaker ...	☐	☐	☐	☐	☐	☐
Majones, remulade o.l. ...	☐	☐	☐	☐	☐	☐
Gulrøtter ... 300	☐	☐	☐	☐	☐	☐
Blomkål/kål/brokkoli ...	☐	☐	☐	☐	☐	☐
Epler/pærer ...	☐	☐	☐	☐	☐	☐
Appelsiner, mandariner o.l. ...	☐	☐	☐	☐	☐	☐
Sukkerholdige leskedrikker ...	☐	☐	☐	☐	☐	☐
Sukkerfrie («Light») leskedrikker	☐	☐	☐	☐	☐	☐
Sjokolade ...	☐	☐	☐	☐	☐	☐
Vafler, kaker o.l. ... 307	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6

ALKOHOL

Hvor ofte pleier du å drikke	øl?	vin?	brennevin?
Aldri, eller noen få ganger i året	☐	☐	☐ 1
1-2 ganger i måneden	☐	☐	☐ 2
Omtrent 1 gang i uken	☐	☐	☐ 3
2-3 ganger i uken	☐	☐	☐ 4
Omtrent hver dag	☐	☐	☐ 5
	308		310

Omtrent hvor ofte har du i løpet av siste år drukket alkohol tilsvarende minst 5 halvflasker øl, en helflaske vin eller 1/4 flaske brennevin?

- Ikke siste år ☐ 1 (311)
- Noen få ganger ☐ 2
- 1 - 2 ganger per måned ☐ 3
- 1 - 2 ganger i uken ☐ 4
- 3 eller flere ganger i uken ☐ 5

I omtrent hvor mange år har ditt alkoholforbruk vært slik du har svart i spørsmålene over? (312) _____ år

SLANKING

Omtrent hvor mange ganger har du bevisst prøvd å slanke deg? Sett 0 hvis ingen forsøk.

- før 20 år (314) _____ ganger
- senere (316) _____ ganger

Hvis du har slanket deg, omtrent hvor mange kilo har du på det meste gått ned i vekt?

- før 20 år (318) _____ kg
- senere (320) _____ kg

Hvilken vekt ville du være tilfreds med (din "trivselsvekt")? (322) _____ kg

UFRIVILLIG URINLEKKASJE

Hvor ofte har du ufrivillig urinlekkasje?

- Aldri (325) ☐ 1
- Ikke mer enn en gang i måneden ☐ 2
- To eller flere ganger i måneden ☐ 3
- Ukentlig eller oftere ☐ 4

Dine kommentarer:

BESVARES BARE AV KVINNER

MENSTRUASJON

Hvor gammel var du da du fikk menstruasjon første gang? (326) _____ år

Hvis du ikke lenger har menstruasjon, hvor gammel var du da den sluttet? (328) _____ år

Når du ser bort fra svangerskap og barselsperiode, har du noen gang vært blødningsfri i minst 6 måneder? (330) Ja ☐ Nei ☐

Hvis "Ja", hvor mange ganger? (331) _____ ganger

Hvis du fremdeles har menstruasjon eller er gravid:

Hvilken dato startet din siste menstruasjon? (333) dag/ mnd/ år ___/___/___

Bruker du vanligvis smertestillende legemidler for å dempe menstruasjonsplager? (339) Ja ☐ Nei ☐

SVANGERSKAP

Hvor mange barn har du født? (340) _____ barn

	Ja	Nei	Usikker
Er du gravid nå? (342)	☐	☐	☐

	Ja	Nei
Har du i forbindelse med svangerskap hatt for høyt blodtrykk og/eller eggehvite (protein) i urinen? (343)	☐	☐

Hvis "Ja", i hvilket svangerskap?

	Svangerskap Første	Senere
For høyt blodtrykk (344)	☐	☐
Eggehvite i urinen (346)	☐	☐

Hvis du har født, fyll ut for hvert barn barnets fødselsår og omtrent antall måneder du ammet barnet.

Barn:	Fødselsår:	Antall måneder med amming:
1	(348) _____	_____
2	_____	_____
3	(356) _____	_____
4	_____	_____
5	(364) _____	_____
6	_____	_____

PREVENSJON OG ØSTROGEN

Bruker du, eller har du brukt:	Nå	Før	Aldri
P-pille (også minipille) (372)	☐	☐	☐
Hormonspiral	☐	☐	☐
Østrogen (tabletter eller plaster) (374)	☐	☐	☐
Østrogen (krem eller stikkpiller)	☐	☐	☐
	1	2	3

Hvis du bruker p-pille, hormonspiral eller østrogen; hvilket merke bruker du nå?

(376) _____

Hvis du bruker eller har brukt p-pille:

Alder da du begynte med P-piller? (380) _____ år

Hvor mange år har du tilsammen brukt P-piller? (382) _____ år

Dersom du har født, hvor mange år brukte du P-piller før første fødsel? (384) _____ år

Hvis du har sluttet å bruke P-piller:

Alder da du sluttet? (386) _____ år

Takk for hjelpen! Husk å postlegge skjemaet idag!

Helseundersøkelsen i Tromsø

English translation of the second questionnaire used in the health survey in Tromsø 1994/95 for subjects younger than 70 years.

Based on translations by K. McCafferty and A. Clancy

TROMSØ HEALTH SURVEY

The main aim of the Tromsø survey is to improve our knowledge of heart and circulatory conditions in order to aid prevention. The survey is also intended to improve our knowledge of cancer and other general conditions, such as allergies, muscle pains and nervous conditions. We would therefore like you to answer some questions about factors that may be relevant for your risk of getting these and other illnesses.

This form is part of the Health Survey, which has been approved by the Norwegian Data Inspectorate and the Regional Board of Research Ethics. The answers will only be used for research purposes and will be treated in strict confidence. The information you give us may later be stored along with information from other public health registers in accordance with the rules laid down by the Data Inspectorate and the Regional Board of Research Ethics.

If you are unsure about what to answer, tick the box that you feel fits best.

The completed form should be sent to us in the enclosed pre-paid envelope.

Thank you in advance for helping us.

Yours sincerely,

Faculty of Medicine
University of Tromsø

National Health
Screening Service

If you do not wish to answer the questionnaire, tick the box below and return the form. Then you will not receive reminders.

I do not wish to answer the questionnaire. ☐

Date for filling in this form: Day/Month/Year

CHILDHOOD/YOUTH

What Norwegian municipality did you live in at the age of 1 year? _____

If you did not live in Norway, give country of residence instead of municipality.

How was your family's economic situation while you were growing up?

- Very good ☐
- Good ☐
- Difficult ☐
- Very difficult ☐

For how much of the first three years of your life
- did you live in a town/city? ____ Years
- did your family have a cat or dog in the home? ____ Years

For how much of the first 15 years of your life
- did you live in a town/city? ____ Years
- did your family have a cat or dog in the home? ____ Years

HOME

Who do you live with?

Tick once for each item and give the number of persons.

	YES	NO	Number
Spouse/partner	☐	☐	_____
Other persons over 18 years	☐	☐	_____
Persons under 18 years	☐	☐	_____

How many of the children go to day care/kindergarten/ nursery school? ____

What type of home do you live in?

- Villa/ detached house ☐
- Farm ☐
- Flat / Apartment ☐
- Terraced /semi-detached house ☐
- Other ☐

How big is your home? _____ m2

Approximately what year was your home built? _____

	YES	NO
Has your home been insulated after 1970?	☐	☐
Do you live on the bottom floor/cellar level?	☐	☐
If "YES", is the floor laid on concrete?	☐	☐

What is the main source of heat in your home?

- Electric heating ☐
- Wood-burning stove ☐
- Central heating system using:
  - Paraffin ☐
  - Electricity ☐

	YES	NO
Do you have fitted carpets in the living-room?	☐	☐
Is there a cat in your home?	☐	☐
Is there a dog in your home?	☐	☐

WORK

If you are in paid or unpaid work, which statement describes your work best?

- I am mainly seated while working (*e.g., at a desk/assembly work*) ☐
- My work requires a lot of walking (*e.g., shop assistant, light industrial work, teaching*) ☐
- My work entails a lot of walking and lifting (*e.g., postman/woman, nurse, building work*) ☐
- I do heavy physical work (*e.g., forestry, heavy agricultural/construction work*) ☐

Do you have any influence on how your work is organised?

- No, not at all ☐
- To a small extent ☐
- Yes, to a large extent ☐
- Yes, I decide myself ☐

	YES	NO
Are you on call; do you work shifts or nights?	☐	☐

Do you do any of the following jobs (full- or part-time)?

Tick one box only for each item.	YES	NO
Driver	☐	☐
Farmer	☐	☐
Fisherman	☐	☐

YOUR OWN ILLNESSES

Have you ever had:

Tick one box only for each item. Give your age at the time. If you have had the condition several times, how old were you last time?

	YES	NO	AGE
Hip fracture	☐	☐	____
Wrist/forearm fracture	☐	☐	____
Whiplash	☐	☐	____
Injury requiring hospital admission	☐	☐	____
Stomach ulcer	☐	☐	____
Duodenal ulcer	☐	☐	____
An operation for stomach/ duodenal ulcer	☐	☐	____
Throat/ neck operation	☐	☐	____

Have you you ever had, or do you still have:

Tick one box only for each item.	YES	NO
Cancer	☐	☐
Epilepsy	☐	☐
Migraine	☐	☐
Chronic bronchitis	☐	☐
Psoriasis	☐	☐
Osteoporosis	☐	☐
Fibromyalgia/fibrositis/ chronic pain syndrome	☐	☐
Psychological problems for which you have sought help	☐	☐
Thyroid disease	☐	☐
Liver disease	☐	☐
Kidney stone	☐	☐
Appendectomy	☐	☐
Allergy and hypersensitivity:		
Atopic eczema (e.g., childhood eczema)	☐	☐
Hand eczema	☐	☐
Hay fever	☐	☐
Food allergy	☐	☐
Other hypersensitivity (not allergy)	☐	☐

How many times have you had a cold, influenza (flue), vomiting/diarrhoea, or similar in the last six months?

_____ times

Have you had any of these in the last two weeks?

YES	NO
☐	☐

ILLNESS IN THE FAMILY

Tick the appropriate box for relatives that have, or have ever had the following illnesses: *Tick "None" if none of your relatives have had the condition.*

	Mother	Father	Brother	Sister	Child	None
Stroke or brain haemorrhage	☐	☐	☐	☐	☐	☐
Myocardial infarction before age 60	☐	☐	☐	☐	☐	☐
Cancer	☐	☐	☐	☐	☐	☐
Asthma	☐	☐	☐	☐	☐	☐
Stomach/ duodenal ulcer	☐	☐	☐	☐	☐	☐
Osteoporosis	☐	☐	☐	☐	☐	☐
Psychological problems	☐	☐	☐	☐	☐	☐
Allergy	☐	☐	☐	☐	☐	☐
Diabetes	☐	☐	☐	☐	☐	☐
-age when they got diabetes	___	___	___	___	___	___

SYMPTOMS

	YES	NO
Do you cough approximately every day of the year?	☐	☐
If "Yes": Is your cough productive ?	☐	☐
Have you had this kind of cough for as long as 3 months in each of the last two years?	☐	☐
Have you had periods of wheezing in your chest?	☐	☐
If "Yes", has this occurred: *Tick one box only for each item.*		
At night	☐	☐
In connection with respiratory infections	☐	☐
In connection with physical exertion	☐	☐
In connection with very cold weather	☐	☐
Have you noticed sudden changes in your pulse or heart rhythm in the last year?	☐	☐

How often do you suffer from sleeplessness?

- Never, or just a few times a year ☐
- 1-2 times a month ☐
- Approximately once a week ☐
- More than once a week ☐

If you suffer from periods of sleeplessness, what times of the year does it affect you most?

- No particular time of year ☐
- Especially during the dark winter months ☐
- Especially during the midnight sun period ☐
- Especially in spring and autumn ☐

Have you in the last twelve months suffered from sleeplessness to the extent that it has affected your ability to work? YES ☐ NO ☐

How often do you suffer from headaches?

- Seldom/Never ☐
- Once a month or more ☐
- Once a week or more ☐
- Every day ☐

Does the thought of getting a serious illness ever worry you?

- Not at all ☐
- Only a little ☐
- Some ☐
- Very much ☐

USE OF HEALTH SERVICES

How many visits have you made during the past year due to your own health or illness? *Tick **0** if you have **not** had such contact*

	Number of times the past year
To a general practitioner (GP)/ Emergency GP	_____
Psychologist or psychiatrist	_____
Other medical specialist (not at a hospital)	_____
Hospital out-patient clinic	_____
Hospital admission	_____
Medical officer at work	_____
Physiotherapist	_____
Chiropractor	_____
Acupuncturist	_____
Dentist	_____
Alternative medical practitioner (homoeopath, foot zone therapist, etc.)	_____
Healer, Faith healer, clairvoyant	_____

MEDICATION AND DIETARY SUPPLEMENTS

Have you for any length of time in the past year used any of the following medicines every day or almost daily? Indicate how many months you used them for. *Write **0** for items you have **not** used.*

Medication:	
Painkillers	_____ mths
Sleeping pills	_____ mths
Tranquilizers	_____ mths
Antidepressants	_____ mths
Allergy drugs	_____ mths
Asthma drugs	_____ mths
Dietary supplements	
Iron tablets	_____ mths
Calcium tablets or bonemeal	_____ mths
Vitamin D supplement	_____ mths
Other vitamin supplements	_____ mths
Cod liver oil or fish oil capsules	_____ mths

Have you in the last 14 days used the following medicines or dietary supplements? *Tick one box only for each item.*

Medicines	YES	NO
Painkillers	☐	☐
Antipyretic drugs (to reduce fever)	☐	☐
Migraine drugs	☐	☐
Eczema cream/ointment	☐	☐
Heart medicine (not blood pressure)	☐	☐
Lipid lowering drugs	☐	☐
Sleeping pills	☐	☐
Tranquilizers	☐	☐
Antidepressants	☐	☐
Other drugs for nervous conditions	☐	☐
Antacids	☐	☐
Gastric ulcer drugs	☐	☐
Insulin	☐	☐
Diabetes tablets	☐	☐
Thyroxin tablets (for metabolic disorder)	☐	☐
Cortisone tablets	☐	☐
Other medicine(s)	☐	☐

Dietary supplements	YES	NO
Iron tablets	☐	☐
Calcium tablets or bonemeal	☐	☐
Vitamin D supplement	☐	☐
Other vitamin supplements	☐	☐
Cod liver oil or fish oil capsules	☐	☐

FRIENDS

How many good friends do you have whom you can talk confidentially with and who give you help when you need it? _____ good friends

Do not count people you live with, but do include other relatives!

How many of these good friends do you have contact with at least once a month? _____

Do you feel you have enough good friends? YES ☐ NO ☐

How often do you normally take part in organised gatherings, e.g., sewing circles, sports clubs, political meetings, religious or other associations?

- Never, or just a few times a year ☐
- 1-2 times a month ☐
- Approximately once a week ☐
- More than once a week ☐

DIET

If you use butter or margarine on your bread, how many slices does a small catering portion normally cover? By this, we mean the portion packs served on planes, in cafés, etc. (i.e., 10-12g)

A catering portion is enough for about ____ slices.

What kind of fat is normally used in **cooking** (not on the bread) in your home?

- Creamery butter ☐
- Hard margarine ☐
- Soft margarine ☐
- Butter/margarine blend ☐
- Oils ☐

What kind of bread (bought or home-made) do you usually eat? *Tick one or two boxes!*

The bread I eat is most similar to

- White bread ☐
- Light textured brown bread ☐
- Ordinary brown bread ☐
- Coarse brown bread ☐
- Crisp bread ☐

How much (in **number** of glasses, cups, potatoes or slices) do you usually eat or drink **daily** of the following foodstuffs? *Tick one box for **each** foodstuff.*

	0	Less than 1	1-2	3-4	5-6	More than 6
Full cream milk (fresh or soured) (glasses)	☐	☐	☐	☐	☐	☐
Semi-skimmed milk (low-fat) (fresh or soured) (glasses)	☐	☐	☐	☐	☐	☐
Skimmed milk (fresh or soured) (glasses)	☐	☐	☐	☐	☐	☐
Tea (cups)	☐	☐	☐	☐	☐	☐
Orange juice (glasses)	☐	☐	☐	☐	☐	☐
Potatoes	☐	☐	☐	☐	☐	☐
Slices of bread in total (incl. crispbread)	☐	☐	☐	☐	☐	☐
Slices of bread with fish (e.g., mackerel in tomato sauce	☐	☐	☐	☐	☐	☐
- lean meat (e.g., ham)	☐	☐	☐	☐	☐	☐
- fat meat (e.g., salami)	☐	☐	☐	☐	☐	☐
- cheese (e.g. Gouda/ Norvegia)	☐	☐	☐	☐	☐	☐
- brown cheese	☐	☐	☐	☐	☐	☐
- smoked cod caviar	☐	☐	☐	☐	☐	☐
- jam and other sweet spreads	☐	☐	☐	☐	☐	☐

How many **times per week** do you normally eat the following foodstuffs? *Tick a box for all foodstuffs listed.*

	Never	Less than 1	1	2-3	4-5	Roughly every day
Yoghurt	☐	☐	☐	☐	☐	☐
Boiled or fried egg	☐	☐	☐	☐	☐	☐
Breakfast cereal/ oat meal, etc.	☐	☐	☐	☐	☐	☐
For dinner						
- meat	☐	☐	☐	☐	☐	☐
- sausage/meatloaf/ meatballs	☐	☐	☐	☐	☐	☐
- fat fish (e.g., salmon/ redfish)	☐	☐	☐	☐	☐	☐
- lean fish (e.g., cod)						
- fishballs/fishpudding/ fishcakes	☐	☐	☐	☐	☐	☐
- vegetables	☐	☐	☐	☐	☐	☐
Mayonnaise, remoulade	☐	☐	☐	☐	☐	☐
Carrots	☐	☐	☐	☐	☐	☐
Cauliflower/cabbage/ broccoli	☐	☐	☐	☐	☐	☐
Apples/pears	☐	☐	☐	☐	☐	☐
Oranges, mandarines	☐	☐	☐	☐	☐	☐
Sweetened soft drinks	☐	☐	☐	☐	☐	☐
Sugarfree ("Light") soft drinks	☐	☐	☐	☐	☐	☐
Chocolate	☐	☐	☐	☐	☐	☐
Waffles, cakes, etc.	☐	☐	☐	☐	☐	☐

ALCOHOL

How often do you usually drink	beer?	wine?	spirits?
Never, or just a few times a year	☐	☐	☐
1-2 times a month	☐	☐	☐
Roughly once a week	☐	☐	☐
2-3 times a week	☐	☐	☐
Roughly every day	☐	☐	☐

Approximately how often in the last year have you drunk alcohol that equals at least 5 small bottles of beer, a bottle of wine, or 1/4 bottle of spirits?

- Not in the last year ☐
- Just a few times ☐
- 1-2 times a month ☐
- 1-2 times a week ☐
- 3 or more times a week ☐

For approximately how many years has your alcohol comsumption been as you described above? _____ years

WEIGHT REDUCTION

About how many times have you deliberately tried to lose weight? *Write 0 if you never have.*

- before age 20 _____ times
- after age 20 _____ times

If you have lost weight, about how many kilos have you ever lost at the most?

- before age 20 _____ times _____ kg
- after age 20 _____ times _____ kg

What weight would you be satisfied with (your "ideal weight")? _____ kg

URINARY INCONTINENCE

How often do you suffer from urinary incontinence?

- Never ☐
- Not more than once a month ☐
- Two or more times a month ☐

Once a week or more ☐

Your comments:

Thank you for helping us! Remember to post the form today!

Tromsø Health Survey

TO BE ANSWERED BY WOMEN ONLY

MENSTRUATION

How old were you when you had your first menstruation? _____ years

If you no longer menstruate, how old were you when you stopped having menstruation? _____ years

Apart from pregnancy and after giving birth, have you ever stopped having menstruation for 6 months or more?

YES ☐ NO ☐

If "Yes", how many times? _____ times

If you still menstruate or are pregnant:

What date did your last menstruation begin?

day/month/year ___ / ___ / ___

Do you normally use painkillers to relieve period pains?

YES ☐ NO ☐

PREGNANCY

How many children have you given birth to? _____ children

Are you pregnant at the moment? YES ☐ NO ☐ Don't know ☐

During pregnancy, have you had high blood pressure and/or proteinuria? YES ☐ NO ☐

If "Yes", during which pregnancy?

	Pregnancy First	Later
High blood pressure	☐	☐
Proteinuria	☐	☐

If you have given birth, fill out for each child the year of birth and approximately how many months you breastfed the child.

Child:	Year of birth:	Number of months breastfed:
1	_____	_____ months
2	_____	_____ months
3	_____	_____ months
4	_____	_____ months
5	_____	_____ months
6	_____	_____ months

CONTRACEPTION AND OESTROGEN

Do you, or have you ever, used:	Now	Used to	Never:
Contraceptive pills (incl.minipill)	☐	☐	☐
A hormonal intrauterine device	☐	☐	☐
Oestrogen (tablets or patches)	☐	☐	☐
Oestrogen (cream or suppositories)	☐	☐	☐

If you use contraceptive pills, hormonal intrauterine device, or oestrogen, what brand do you currently use?

_____

If you use, or have ever used, contraceptive pills:

Age when you began taking the pill? _____years

How many years in total have you taken the pill? _____years

If you have given birth, how many years did you take the pill before your first child? _____years

If you have stopped taking the pill:

Age when you stopped? _____years

Helseundersøkelsen i Tromsø

for dem som er 70 år og eldre.

Hovedformålet med Tromsøundersøkelsene er å skaffe ny kunnskap om hjerte-karsykdommer for å kunne forebygge dem. De skal også øke kunnskapen om kreftsykdommer og alminnelige plager som f.eks. allergier, smerter i muskulatur og nervøse lidelser. Endelig skal de gi kunnskap om hvorledes den eldste delen av befolkningen har det. Vi ber deg derfor svare på spørsmålene nedenfor.

Skjemaet er en del av Helseundersøkelsen som er godkjent av Datatilsynet og av Regional komite for medisinsk forskningsetikk. Svarene brukes bare til forskning og behandles strengt fortrolig. Opplysningene kan senere bli sammenholdt med informasjon fra andre offentlige helseregistre etter de regler som Datatilsynet og Regional komite for medisinsk forskningsetikk gir.

Hvis du er i tvil om hva du skal svare, sett kryss i den ruten som du synes passer best.

Det utfylte skjema sendes i vedlagte svarkonvolutt. Portoen er betalt.

På forhånd takk for hjelpen!

Med vennlig hilsen

Fagområdet medisin
Universitetet i Tromsø — Statens helseundersøkelser

Hvis du ikke ønsker å besvare spørreskjemaet, sett kryss i ruten under og returner skjemaet. Da slipper du purring.

Jeg ønsker ikke å besvare spørreskjemaet ..... 17 ☐

Dato for utfylling av skjema: ..... 18 Dag ____ Mnd ____ År ____

OPPVEKST

I hvilken kommune bodde du da du fylte 1 år?

..... 24-28

Hvis du ikke bodde i Norge, oppgi land i stedet for kommune.

Hvordan var de økonomiske forhold i familien under din oppvekst?

- Meget gode ..... 29 ☐ 1
- Gode ☐ 2
- Vanskelige ☐ 3
- Meget vanskelige ☐ 4

Hvor gamle ble dine foreldre?

- Mor ble ..... 30 ____ år
- Far ble ..... 32 ____ år

BOLIG

Hvem bor du sammen med?

Sett ett kryss for hvert spørsmål og angi antall.	Ja	Nei	Antall
Ektefelle/samboer 34	☐	☐	
Andre personer over 18 år 35	☐	☐	____
Personer under 18 år 38	☐	☐	____

Hvilken type bolig bor du i?

- Enebolig/villa ..... 41 ☐ 1
- Gårdsbruk ☐ 2
- Blokk/terrasseleilighet ☐ 3
- Rekkehus/2-4 mannsbolig ☐ 4
- Annen bolig ☐ 5

Hvor lenge har du bodd i boligen du bor i nå? ..... 42 ____ år

	Ja	Nei
Er boligen tilpasset til dine behov? 44	☐	☐
Hvis "Nei", er det problemer med:		
Plassen i boligen 45	☐	☐
Ujevn, for høy eller for lav temperatur 46	☐	☐
Trapper 47	☐	☐
Toalett 48	☐	☐
Bad/dusj 49	☐	☐
Vedlikehold 50	☐	☐
Annet (spesifiser) 51	☐	☐
Ønsker du å flytte til en eldrebolig? 52	☐	☐

TIDLIGERE ARBEID OG ØKONOMI

Hvordan vil du beskrive det arbeidet du hadde de siste 5-10 årene før du ble pensjonist?

- For det meste stillesittende arbeid? ..... 53 ☐ 1
  (f.eks. skrivebordsarbeid, montering)
- Arbeid som krever at du går mye? ☐ 2
  (f.eks. ekspeditørarbeid, husmor, undervisning)
- Arbeid hvor du går og løfter mye? ☐ 3
  (f.eks. postbud, pleier, bygningsarbeid)
- Tungt kroppsarbeid? ☐ 4
  (f.eks. skogsarb., tungt jordbruksarb., tungt bygn.arb.)

Har du hatt noen av følgende yrker (heltid eller deltid)?

Sett ett kryss for hvert spørsmål.	Ja	Nei
Sjåfør 54	☐	☐
Bonde/gårdbruker 55	☐	☐
Fisker 56	☐	☐

Hvor gammel var du da du ble pensjonert? ..... 57 ____ år

Hva slags pensjon har du?

- Minstepensjon ..... 59 ☐
- Tilleggspensjon ..... 60 ☐

Hvordan er din økonomi nå?

- Meget god ..... 61 ☐ 1
- God ☐ 2
- Vanskelig ☐ 3
- Meget vanskelig ☐ 4

HELSE OG SYKDOM

Er helsen din blitt forandret det siste året?
- Ja, dårligere ..... 62 ☐ 1
- Nei, uforandret ..... ☐ 2
- Ja, bedre ..... ☐ 3

Hvordan synes du at helsen din er nå i forhold til andre på samme alder?
- Mye dårligere ..... 63 ☐ 1
- Litt dårligere ..... ☐ 2
- Omtrent lik ..... ☐ 3
- Litt bedre ..... ☐ 4
- Mye bedre ..... ☐ 5

EGNE SYKDOMMER

Har du noen gang hatt:
Sett ett kryss for hvert spørsmål. Oppgi alderen ved hendelsen. Hvis det har skjedd flere ganger, hvor gammel var du siste gang?

	Ja	Nei	Alder
Lårhalsbrudd 64	☐	☐	_____
Brudd ved håndledd/underarm 67	☐	☐	_____
Nakkesleng (whiplash) 70	☐	☐	_____
Skade som førte til sykehusinnleggelse 73	☐	☐	_____
Sår på magesekken 76	☐	☐	_____
Sår på tolvfingertarmen 79	☐	☐	_____
Magesår-operasjon 82	☐	☐	_____
Operasjon på halsen 85	☐	☐	_____

Har du eller har du hatt:
Sett ett kryss for hvert spørsmål.

	Ja	Nei
Kreftsykdom 88	☐	☐
Epilepsi (fallesyke)	☐	☐
Migrene	☐	☐
Parkinsons sykdom	☐	☐
Kronisk bronkitt	☐	☐
Psoriasis 93	☐	☐
Benskjørhet (osteoporose)	☐	☐
Fibromyalgi/fibrositt/kronisk smertesyndrom	☐	☐
Psykiske plager som du har søkt hjelp for	☐	☐
Stoffskiftesykdom (skjoldbruskkjertel)	☐	☐
Sykdom i leveren 98	☐	☐
Gjentatt, ufrivillig urinlekkasje	☐	☐
Grønn stær	☐	☐
Grå stær	☐	☐
Slitasjegikt (artrose)	☐	☐
Leddgikt 103	☐	☐
Nyrestein	☐	☐
Blindtarmsoperasjon	☐	☐
Allergi og overfølsomhet		
Atopisk eksem (f.eks. barneeksem)	☐	☐
Håndeksem	☐	☐
Høysnue 108	☐	☐
Matvareallergi	☐	☐
Annen overfølsomhet (ikke allergi)	☐	☐

Hvor mange ganger har du hatt forkjølelse, influensa, "ræksjuka" og lignende siste halvår? 111 ____ ganger

	Ja	Nei
Har du hatt dette de siste 14 dager? 113	☐	☐

SYKDOM I FAMILIEN

Kryss av for de slektningene som har eller har hatt noen av sykdommene:
Kryss av for "Ingen" hvis ingen av slektningene har hatt sykdommen.

	Mor	Far	Bror	Søster	Barn	Ingen
Hjerneslag eller hjerneblødning 114	☐	☐	☐	☐	☐	☐
Hjerteinfarkt før 60 års alder 120	☐	☐	☐	☐	☐	☐
Kreftsykdom 126	☐	☐	☐	☐	☐	☐
Høyt blodtrykk 132	☐	☐	☐	☐	☐	☐
Astma 138	☐	☐	☐	☐	☐	☐
Benskjørhet (osteoporose) 144	☐	☐	☐	☐	☐	☐
Slitasjegikt (artrose) 150	☐	☐	☐	☐	☐	☐
Psykiske plager 156	☐	☐	☐	☐	☐	☐
Alderdomssløvhet 162	☐	☐	☐	☐	☐	☐
Diabetes (sukkersyke) 168	☐	☐	☐	☐	☐	☐
– alder da de fikk diabetes 174	__	__	__	__	__	

SYMPTOMER

	Ja	Nei
Hoster du omtrent daglig i perioder av året? 184	☐	☐
Hvis "Ja":		
Er hosten vanligvis ledsaget av oppspytt? 185	☐	☐
Har du hatt slik hoste så lenge som i en 3 måneders periode i begge de to siste år? 186	☐	☐
Har du hatt episoder med piping i brystet? 187	☐	☐
Hvis "Ja", har dette oppstått:		
Sett ett kryss for hvert spørsmål.		
Om natten 188	☐	☐
Ved luftveisinfeksjoner	☐	☐
Ved fysiske anstrengelser	☐	☐
Ved sterk kulde 191	☐	☐
Har du merket anfall med plutselig endring i pulsen eller hjerterytmen siste år? 192	☐	☐
Har du gått ned i vekt siste året? 193	☐	☐
Hvis "Ja":		
Hvor mange kilo? 194	_____ kg	

Hvor ofte er du plaget av søvnløshet?
- Aldri, eller noen få ganger i året 196 ☐ 1
- 1-2 ganger i måneden ☐ 2
- Omtrent en gang i uken ☐ 3
- Mer enn en gang i uken ☐ 4

Hvis du er plaget av søvnløshet i perioder, når på året er du mest plaget?
- Ingen spesiell tid 197 ☐ 1
- Særlig i mørketiden ☐ 2
- Særlig i midnattsoltiden ☐ 3
- Særlig vår og høst ☐ 4

	Ja	Nei
Pleier du å ta en lur på dagen? 198	☐	☐
Føler du at du vanligvis får nok søvn?	☐	☐

Er du plaget av:	Nei	Litt	I stor grad
Svimmelhet 200	☐	☐	☐
Dårlig hukommelse	☐	☐	☐
Kraftløshet	☐	☐	☐
Forstoppelse 203	☐	☐	☐

Hender det at tanken på å få alvorlig sykdom bekymrer deg?

- Ikke i det hele tatt ..... 204 ☐
- Bare i liten grad ☐
- En del ☐
- Ganske mye ☐

LEGEMLIG FUNKSJONER

Klarer du selv disse gjøremålene i det daglige uten hjelp fra andre?	Ja	Med noe hjelp	Nei
Gå innendørs i samme etasje 205	☐	☐	☐
Gå i trapper	☐	☐	☐
Gå utendørs	☐	☐	☐
Gå ca. 500 meter	☐	☐	☐
Gå på toalettet	☐	☐	☐
Vaske deg på kroppen 210	☐	☐	☐
Bade eller dusje	☐	☐	☐
Kle på og av deg	☐	☐	☐
Legge deg og stå opp	☐	☐	☐
Spise selv	☐	☐	☐
Lage varm mat 215	☐	☐	☐
Gjøre lett husarbeid (f.eks. oppvask)	☐	☐	☐
Gjøre tyngre husarbeid (f.eks. gulvvask)	☐	☐	☐
Gjøre innkjøp	☐	☐	☐
Ta bussen	☐	☐	☐

	Ja	Vanskelig	Nei
Kan du høre vanlig tale (evt. med høreapparat)? 220	☐	☐	☐
Kan du lese (evt. med briller)? 221	☐	☐	☐

Er du avhengig av noen av disse hjelpemidlene?

	Ja	Nei
Stokk 222	☐	☐
Krykke	☐	☐
Gåstol (rullator)	☐	☐
Rullestol	☐	☐
Høreapparat	☐	☐
Trygghetsalarm 227	☐	☐

BRUK AV HELSEVESENET

Hvor mange ganger har du siste året, på grunn av egen helse eller sykdom, vært: *Sett 0 hvis du ikke har hatt slik kontakt.*	Antall ganger siste år
Hos vanlig lege/legevakt 228	_____
Hos psykolog eller psykiater	_____
Hos annen legespesialist utenfor sykehus	_____
På poliklinikk 234	_____
Innlagt i sykehus	_____
Hos fysioterapeut	_____
Hos kiropraktor 240	_____
Hos akupunktør	_____
Hos tannlege	_____
Hos fotterapeut 246	_____
Hos naturmedisiner (homøopat, soneterapeut o.l.)	_____
Hos håndspålegger, synsk eller "leser"	_____

Har du hjemmehjelp?	Ja	Nei
Privat 252	☐	☐
Kommunal	☐	☐

Har du hjemmesykepleie? ☐ ☐

Er du fornøyd med helse- og hjemmetjenesten i kommunen?	Ja	Nei	Vet ikke
Prinsippet med fast lege 255	☐	☐	☐
Hjemmesykepleien	☐	☐	☐
Hjemmehjelpen	☐	☐	☐

Er du trygg på at du kan få hjelp av helse- og hjemmetjenesten hvis du trenger det?

- Trygg ..... 250 ☐ 1
- Ikke trygg ☐ 2
- Svært utrygg ☐ 3
- Vet ikke ☐ 4

LEGEMIDLER OG KOSTTILSKUDD

Har du det siste året periodevis brukt noen av de følgende midler daglig eller nesten daglig? Angi hvor mange måneder du brukte dem. *Sett 0 hvis du ikke har brukt midlene.*

Legemidler

- Smertestillende ..... 259 _____ mnd.
- Sovemedisin _____ mnd.
- Beroligende midler _____ mnd.
- Medisin mot depresjon ..... 265 _____ mnd.
- Allergimedisin _____ mnd.
- Astmamedisin _____ mnd.
- Hjertemedisin (ikke blodtrykksmedisin) ..... 271 _____ mnd.
- Insulin _____ mnd.
- Tabletter mot diabetes (sukkersyke) _____ mnd.
- Tabletter mot lavt stoffskifte (thyroxin) ..... 277 _____ mnd.
- Kortisontabletter _____ mnd.
- Midler mot forstoppelse _____ mnd.

Kosttilskudd

- Jerntabletter ..... 283 _____ mnd.
- Vitamin D-tilskudd _____ mnd.
- Andre vitamintilskudd _____ mnd.
- Kalktabletter eller benmel ..... 289 _____ mnd.
- Tran eller fiskeoljekapsler _____ mnd.

FAMILIE OG VENNER

Har du nær familie som kan gi deg hjelp og støtte når du trenger det? 293	Ja ☐	Nei ☐
Hvis "Ja": Hvem kan gi deg hjelp?		
Ektefelle/samboer 294	☐	
Barn	☐	
Andre	☐	

Hvor mange gode venner har du som du kan snakke fortrolig med og gi deg hjelp når du trenger det? ..297 ____ gode venner
Tell ikke med dem du bor sammen med, men ta med andre slektninger!

	Ja	Nei
Føler du at du har nok gode venner? 299	☐	☐

Føler du at du hører med i et fellesskap (gruppe av mennesker) som stoler på hverandre og føler forpliktelse overfor hverandre (f.eks. i politisk parti, religiøs gruppe, slekt, naboskap, arbeidsplass eller organisasjon)?

- Sterk tilhørighet ..... 300 ☐ 1
- Noe tilhørighet ☐ 2
- Usikkert ☐ 3
- Liten eller ingen tilhørighet ☐ 4

Hvor ofte tar du vanligvis del i foreningsvirksomhet som f.eks. syklubb, idrettslag, politiske lag, religiøse eller andre foreninger?

- Aldri, eller noen få ganger i året ..... 301 ☐ 1
- 1-2 ganger i måneden ..... ☐ 2
- Omtrent en gang i uken ..... ☐ 3
- Mer enn en gang i uken ..... ☐ 4

KOSTVANER

Hvor mange måltider spiser du vanligvis daglig (middag og brødmåltid)? ..... 302 Antall _____

Hvor mange ganger i uken spiser du varm middag? ..... 304 _____

Hva slags type brød (kjøpt eller hjemmebakt) spiser du vanligvis?

Sett ett eller to kryss.	Loff	Fint brød	Knelp-brød	Grov-brød	Knekke-brød
Brødtypen ligner mest på:	☐ 306	☐	☐	☐	☐ 310

Hva slags fett blir til vanligvis brukt til *matlaging* (ikke på brødet) i din husholdning?

- Meierismør ..... 311 ☐
- Hard margarin ..... ☐
- Bløt (Soft) margarin ..... ☐
- Smør/margarin blanding ..... ☐
- Oljer ..... 315 ☐

Hvor mye (i antall glass, poteter eller brødskiver) spiser/drikker du vanligvis daglig av følgende matvarer?

Kryss av for alle matvarene.	Ingen	Mindre enn 1	1-2	3 og mer
Melk alle sorter (glass) 316	☐	☐	☐	☐
Appelsinjuice (glass)	☐	☐	☐	☐
Poteter	☐	☐	☐	☐
Brødskiver totalt (inkl. knekkebrød) ...	☐	☐	☐	☐
Brødskiver med				
– fiskepålegg (f.eks. makrell i tomat)	☐	☐	☐	☐
– gulost	☐	☐	☐	☐
– kaviar 322	☐ 1	☐ 2	☐ 3	☐ 4

Hvor mange ganger i uka spiser du vanligvis følgende matvarer?

Kryss av for alle matvarene.

	Aldri	Sjeldnere enn 1	1	2 og mer
Yoghurt 323	☐	☐	☐	☐
Kokt eller stekt egg	☐	☐	☐	☐
Frokostblanding/havregryn o.l.	☐	☐	☐	☐
Middag med				
– rent kjøtt	☐	☐	☐	☐
– feit fisk (f.eks. laks/uer)	☐	☐	☐	☐
– mager fisk (f.eks. torsk) 328	☐	☐	☐	☐
– grønnsaker (rå eller kokte)	☐	☐	☐	☐
Gulrøtter (rå eller kokte)	☐	☐	☐	☐
Blomkål/kål/brokkoli	☐	☐	☐	☐
Epler/pærer	☐	☐	☐	☐
Appelsiner, mandariner o.l. 333	☐ 1	☐ 2	☐ 3	☐ 4

TRIVSEL

Hvordan trives du med å bli gammel - alt i alt?

- Godt ..... 334 ☐ 1
- Ganske bra ..... ☐ 2
- Opp og ned ..... ☐ 3
- Dårlig ..... ☐ 4

Hvordan ser du på livet fremover?

- Lyst ..... 335 ☐ 1
- Ikke så verst ..... ☐ 2
- Nokså bekymret ..... ☐ 3
- Mørkt ..... ☐ 4

BESVARES BARE AV KVINNER

MENSTRUASJON

Hvor gammel var du da du fikk menstruasjon første gang? ..... 336 _____ år

Hvor gammel var du da menstruasjonen sluttet? ..... 338 _____ år

SVANGERSKAP

Hvor mange barn har du født? ..... 340 _____ barn

Hvis du har født, fyll ut for hvert barn barnets fødselsår og omtrent antall måneder du ammet barnet.
Hvis du har født mer enn 6 barn, noter fødselsår og antall måneder med amming for dem nederst på siden.

Barn:	Fødselsår:	Antall måneder med amming:
1	342 _____	_____
2	346 _____	_____
3	_____	_____
4	_____	_____
5	358 _____	_____
6	_____	_____

Har du i forbindelse med svangerskap hatt for høyt blodtrykk og/eller eggehvite (protein) i urinen? ..... 366 Ja ☐ Nei ☐

Hvis "Ja", i hvilket svangerskap?

	Svangerskap Første	Senere
For høyt blodtrykk 367	☐	☐
Eggehvite i urinen 369	☐	☐

ØSTROGEN-MEDISIN

Bruker du, eller har du brukt, østrogen-medisin?

	Nå	Før	Aldri
Tabletter eller plaster 371	☐	☐	☐
Krem eller stikkpiller 372	☐	☐	☐

Hvis du bruker østrogen, hvilket merke bruker du nå?

..... 373

Dine kommentarer:

Takk for hjelpen! Husk å postlegge skjemaet idag!
Helseundersøkelsen i Tromsø

English translation of the second questionnaire used in the health survey in Tromsø 1994/95 for subjects 70 years or older.

Based on translations by Kevin McCafferty and Anne Clancy.

TROMSØ HEALTH SURVEY for the over 70s

The main aim of the Tromsø survey is to improve our knowledge of heart and circulatory conditions in order to aid prevention. The survey is also intended to improve our knowledge of cancer and other general conditions, such as allergies, muscle pains and nervous conditions. The ultimate aim is to gain an overview of the general health of the elderly population. We would therefore like you to answer the questions below.

This form is part of the Health Survey, which has been approved by the Norwegian Data Inspectorate and the Regional Board of Research Ethics. The answers will only be used for research purposes and will be treated in strict confidence. The information you give us may later be stored along with information from other public health registers in accordance with the rules laid down by the Data Inspectorate and the Regional Board of Research Ethics.

If you are unsure about what to answer, tick the box that you feel fits best.

The completed form should be sent to us in the enclosed pre-paid envelope.

Thank you in advance for helping us.

Yours sincerely,

Faculty of Medicine
University of Tromsø

National Health
Screening Service

If you do not wish to answer the questionnaire, tick the box below and return the form. Then you will not receive reminders.

I do not wish to answer the questionnaire. ☐

Date for filling in this form: Day/Month/Year

CHILDHOOD/YOUTH

What Norwegian municipality did you live in at the age of 1 year?

If you did not live in Norway, give country instead of municipality.

How was your family's financial situation while you were growing up?

- Very good ☐
- Good ☐
- Difficult ☐
- Very difficult ☐

How old were your parents when they died?

- Mother _____ years
- Father _____ years

HOME

Who do you live with?
Tick one box for each item and give the number of persons.

	YES	NO	Number
Spouse/partner	☐	☐	_____
Other persons over 18 years	☐	☐	_____
Persons under 18 years	☐	☐	_____

What type of home do you live in?

- Villa/detached house ☐
- Farm ☐
- Apartment/flat in block/terrace ☐
- Terraced/semi-detached house ☐
- Other ☐

How long have you lived in your present home? ____years

Is your home adapted to your needs? YES ☐ NO ☐
If "No", do you have problems with:

- Space ☐
- Variable temperature/too cold/too warm ☐
- Stairs ☐
- Toilet ☐
- Bath/shower ☐
- Maintenance ☐
- Other (please specify) ☐

Would you like to move into a retirement home?
YES ☐ NO ☐

PREVIOUS WORK AND FINANCIAL SITUATION

Which statement best describes the type of work you did for the last 5-10 years before you retired?

- I was mainly seated while working (*e.g., desk/assembly work*) ☐
- My work required a lot of walking (*e.g., shop assistant, housewife, teaching*) ☐
- My work required a lot of walking and lifting (*e.g., postman, nurse, construction work*) ☐
- I did heavy physical work (*e.g., forestry, heavy agricultural work, heavy construction work*) ☐

Did you do any of the following jobs (full- or part-time)?
Tick one box only for each item.

	YES	NO
Driver	☐	☐
Farmer	☐	☐
Fisherman	☐	☐

How old were you when you retired? _____ years

What kind of pension do you have?

- Basic state pension ☐
- Additional pension ☐

How is your current financial situation?

- Very good ☐
- Good ☐
- Difficult ☐
- Very difficult ☐

HEALTH AND ILLNESS

Has your state of health changed in the last year?

- Yes, it has got worse ☐
- No, unchanged ☐
- Yes, it has got better ☐

How do you feel your health is now compared to others of your age?

- Much worse ☐
- A little worse ☐
- About the same ☐
- A little better ☐
- Much better ☐

YOUR OWN ILLNESSES

Have you ever had:
*Tick one box only for each item. Give your age at the time. If you have had the condition several times, how old were you **last time**?*

	YES	NO	AGE
Hip fracture	☐	☐	_____
Wrist /forearm fracture	☐	☐	_____
Whiplash	☐	☐	_____
Injury requiring hospital admission	☐	☐	_____
Stomach ulcer	☐	☐	_____
Duodenal ulcer	☐	☐	_____
Stomach/duodenal ulcer operation	☐	☐	_____
Throat/neck surgery	☐	☐	_____

Have you ever had, or do you still have:

Tick one box only for each item.	YES	NO
Cancer	☐	☐
Epilepsy	☐	☐
Migraine	☐	☐
Chronic bronchitis	☐	☐
Psoriasis	☐	☐
Osteoporosis	☐	☐
Fibromyalgia/fibrositis/ chronic pain syndrom	☐	☐
Psychological problems for which you have sought help	☐	☐
Thyroid disease	☐	☐
Liver disease	☐	☐
Thyroid disease	☐	☐
Liver disease	☐	☐
Recurrent urinary incontinence	☐	☐
Glaucoma	☐	☐
Cataract	☐	☐
Arthrosis (osteoarthritis)	☐	☐
Rheumatoid arthritis	☐	☐
Kidney stone	☐	☐
Appendectomy	☐	☐
Allergy and hypersensitivity		
Atopic eczema (e.g., childhood eczema)	☐	☐
Hand eczema	☐	☐
Hay fever	☐	☐
Food allergy	☐	☐
Other hypersensitivity (not allergy)	☐	☐

How many times have you had a cold, influenza (flue), diarrhea/vomiting, or similar in the last six months?
_____ times

Have you had any of these in the last two weeks?
YES ☐ NO ☐

ILLNESS IN THE FAMILY

Tick off relatives who have, or have ever had, any of the following conditions:
Tick "None" for conditions which none of your relatives have had.

	Mother	Father	Brother	Sister	Child	None
Stroke or brain haemorrhage	☐	☐	☐	☐	☐	☐
Myocardial infarction before age 60	☐	☐	☐	☐	☐	☐
Cancer	☐	☐	☐	☐	☐	☐
Hypertension	☐	☐	☐	☐	☐	☐
Asthma	☐	☐	☐	☐	☐	☐
Osteoporosis	☐	☐	☐	☐	☐	☐
Arthrosis (osteoarthritis)	☐	☐	☐	☐	☐	☐
Psychological problems	☐	☐	☐	☐	☐	☐
Dementia	☐	☐	☐	☐	☐	☐
Diabetes	☐	☐	☐	☐	☐	☐
-age when they got diabetes	___	___	___	___	___	___

SYMPTOMS

	YES	NO
Do you cough daily for periods of the year?	☐	☐
If "Yes":		
Is your cough productive?	☐	☐
Have you had this kind of cough for as long as 3 months in each of the last two years?	☐	☐
Have you had periods of wheezing in your chest?	☐	☐
If "Yes", has this occurred: *Tick one box only for each item.*		
At night	☐	☐
In connection with respiratory infections	☐	☐
In connection with physical exertion	☐	☐
In connection with very cold weather	☐	☐
Have you noticed sudden changes in your pulse or heart rhythm in the last year?	☐	☐
Have you lost weight in the last year?	☐	☐
If "Yes": How many kilograms?	_____ kg	

How often do you suffer from sleeplessness?

- Never, or just a few times a year ☐
- 1-2 times a month ☐
- Approximately once a week ☐
- More than once a week ☐

If you suffer from periods of sleeplessness, what times of the year does it affect you most?

- No particular time of year ☐
- Especially during the 'dark winter months' ☐
- Especially during the midnight sun period ☐
- Especially in spring and autumn ☐

Do you usually take a nap during the day? YES ☐ NO ☐

Do you feel that you normally get enough sleep? YES ☐ NO ☐

	No	A little	A lot
Do you suffer from:	☐	☐	☐
Dizziness	☐	☐	☐
Poor memory	☐	☐	☐
Lack of energy	☐	☐	☐
Constipation	☐	☐	☐

Does the thought of getting a serious illness ever worry you?

- Not at all ☐
- Only a little ☐
- Some ☐
- Very much ☐

BODILY FUNCTIONS

Can you manage the following everyday activities on your own without help from others?

	Yes	With some help	No
Walking indoors on one level	☐	☐	☐
Walking up/down stairs	☐	☐	☐
Walking outdoors	☐	☐	☐
Walking approx. 500 metres	☐	☐	☐
Going to the toilet	☐	☐	☐
Washing yourself	☐	☐	☐
Taking a bath/shower	☐	☐	☐
Dressing and undressing	☐	☐	☐
Getting in and out of bed	☐	☐	☐
Eating meals	☐	☐	☐
Cooking ☐	☐	☐	
Doing light housework (e.g., washing up)	☐	☐	☐
Doing heavier housework (e.g., cleaning floors)	☐	☐	☐
Going shopping	☐	☐	☐
Taking the bus	☐	☐	☐

	Yes	With difficulty	No
Can you hear normal speech (if necessary with a hearing aid)?	☐	☐	☐
Can you read (if necessary with glasses)?	☐	☐	☐

Are you dependent on any of the following aids?

	Yes	No
Walking stick	☐	☐
Crutches	☐	☐
Walking frame/Zimmer frame	☐	☐
Wheelchair	☐	☐
Hearing aid	☐	☐
Safety alarm device	☐	☐

USE OF HEALTH SERVICES

How many visits have you made during the past year due to your own health or illness:

*Tick **0** if you have **not** had such contact*

	Number of times the past year
To a general practitioner (GP)/ emergency GP	____
Psychologist or psychiatrist	____
Other medical specialist (not at a hospital)	____
Hospital out-patient clinic	____
Hospital admission	____
Physiotherapist	____
Chiropractor	____
Acupuncturist	____
Dentist	____
Chiropodist	____
Alternative medical practitioner (homoeopath, foot zone therapist, etc.)	____
Healer, Faith healer, clairvoyant	____

	Yes	No
Do you have domestic help?		
Private	☐	☐
Municipal	☐	☐
Do you receive services from the district nurse?	☐	☐

Are you pleased with the health care and home assistance services your municipality supplies?

	Yes	No	Don't know
Assigned family GP	☐	☐	☐
District nurse	☐	☐	☐
Home assistance	☐	☐	☐

Do you feel confident that you can receive the health care and home assistance you require if you need it?

- Confident ☐
- Not confident ☐
- Very unsure ☐
- Don't know ☐

MEDICATION AND DIETARY SUPPLEMENTS

Have you for any length of time in the past year used any of the following medicines every day or almost daily? Indicate how many months you used them for.

*Write **0** for items you have **not** used.*

Medication:

Painkillers	_____ mths
Sleeping pills	_____ mths
Tranquillizers	_____ mths
Antidepressants	_____ mths
Allergy drugs	_____ mths
Asthma drugs	_____ mths
Heart medicine (not blood pressure)	_____ mths
Insulin	_____ mths
Diabetes tablets	_____ mths
Thyroxin tablets (for metabolic disorder)	_____ mths
Cortisone tablets	_____ mths
Remedies for constipation	_____ mths

Dietary supplements:

Iron tablets	_____ mths
Vitamin D supplement	_____ mths
Other vitamin supplements	_____ mths
Calcium tablets or bonemeal	_____ mths
Cod liver oil or fish oil capsules	_____ mths

FAMILY AND FRIENDS

Do you have close relatives who can give you help and support when you need it? Yes ☐ No ☐

If "Yes", who can give you help?

- Spouse/partner ☐
- Children ☐
- Others ☐

How many good friends do you have whom you can talk confidentially with and who give you help when you need it?

_____good friends

Do not count people you live with, but do include other relatives!

Do you feel you have enough good friends? Yes ☐ No ☐

Do you feel that you belong to a community or group of people who can depend on each other and who feel committed to each other (e.g., a political party, religious group, relatives, neighbours, work place, or organisation)?

- Strong sense of belonging ☐
- Some sense of belonging ☐
- Not sure ☐
- Little or no sense of belonging ☐

How often do you normally take part in organised gatherings, e.g., sewing circles, sports clubs, political meetings, religious or other associations?

- Never, or just a few times a year ☐
- 1-2 times a month ☐
- Approximately once a week ☐
- More than once a week ☐

DIET

How many meals a day do you normally eat (dinner and smaller meals)? _____ Number

How many times a week do you eat a hot dinner? _____ Number

What kind of bread (bought or home-made) do you usually eat? *Tick one or two boxes!*

The bread I eat is most similar to

- White bread ☐
- Light textured brown bread ☐
- Ordinary brown bread ☐
- Coarse brown bread ☐
- Crisp bread ☐

What kind of fat is normally used in **cooking** (not on the bread) in your home?

- Creamery butter ☐
- Hard margarine ☐
- Soft margarine ☐
- Butter/margarine blend ☐
- Oils ☐

How much (in **number** of glasses, cups, potatoes or slices) do you usually eat or drink **daily** of the following foodstuffs? *Tick one box for **each** foodstuff.*

	0	Less than 1	1-2	3-4	5-6	6-
Milk of all types (glasses)	☐	☐	☐	☐	☐	☐
Orange juice (glasses)	☐	☐	☐	☐	☐	☐
Potatoes	☐	☐	☐	☐	☐	☐
Slices of bread in total (incl. crispbread)	☐	☐	☐	☐	☐	☐
Slices of bread with fish (e.g., mackerel in tomato sauce)	☐	☐	☐	☐	☐	☐
- cheese (e.g., Norwegia)	☐	☐	☐	☐	☐	☐
- smoked cod caviar	☐	☐	☐	☐	☐	☐

How many **times per week** do you normally eat the following foodstuffs? *Tick a box for **all** foodstuffs listed.*

	Never	Less than 1	1	2-3	4-5	Roughly every day
Yoghurt	☐	☐	☐	☐	☐	☐
Boiled or fried egg	☐	☐	☐	☐	☐	☐
Breakfast cereal/ oat meal, etc.	☐	☐	☐	☐	☐	☐
For dinner						
- meat	☐	☐	☐	☐	☐	☐
- fat fish (e.g., salmon/ redfish)	☐	☐	☐	☐	☐	☐
- lean fish (e.g., cod)	☐	☐	☐	☐	☐	☐
- vegetables (raw or cooked)	☐	☐	☐	☐	☐	☐
Carrots (raw or cooked)	☐	☐	☐	☐	☐	☐
Cauliflower/cabbage/broccoli	☐	☐	☐	☐	☐	☐
Apples/pears	☐	☐	☐	☐	☐	☐
Oranges, mandarines, etc.	☐	☐	☐	☐	☐	☐

WELL BEING

How content do you generally feel with growing old?

- Good ☐
- Quite good ☐
- Up and down ☐
- Bad ☐

What is your view of the future?

- Bright ☐
- Not too bad ☐
- Quite worried ☐
- Dark ☐

TO BE ANSWERED BY WOMEN ONLY

MENSTRUATION

How old were you when you had your first menstruation? _____ years

How old were you when you stopped having menstruations? _____ years

PREGNANCY

How many children have you given birth to? _____children

If you have given birth, fill out for each child the year of birth and approximately how many months you breastfed the child. If you have given birth to more than 6 children, note their birthyear and number of months you breastfed at the space provided below for comments.

Child:	Year of birth:	Number of months breastfed:
1	_____	_____ months
2	_____	_____ months
3	_____	_____ months
4	_____	_____ months
5	_____	_____ months
6	_____	_____ months

During pregnancy, have you had high blood pressure and/or proteinuria? Yes ☐ No ☐

If "Yes", during which pregnancy?

	Pregnancy First	Later
High blood pressure	☐	☐
Proteinuria	☐	☐

OESTROGEN

Do you, or have you ever used oestrogen:

	Now	Used to	Never
Tablets or patches	☐	☐	☐
Cream or suppositories	☐	☐	☐

If you use oestrogen, what brand do you currently use?

_____

Your comments:

Thank you for helping us! Remember to post the form today! **Tromsø Health Survey**

APPENDIX B

Ultrasound measurement form

Information leaflets for CT study

CT measurement form

SPESIALUNDERSØKELSEN '94-95

ULTRALYDUNDERSØKELSE AV BUKAORTA

Klientens initialer ☐☐☐

Undersøker ☐

Aorta

	Transversal mål	Anterioposterior mål
✓ Nyrearterienivå	☐☐☐	☐☐☐
1 cm proximalt for nyrearterie	☐☐☐	☐☐☐
1 cm distalt for nyrearterie	☐☐☐	☐☐☐
✓ Like før bifurkatur	☐☐☐	☐☐☐
✓ Maksimal-mål distalt for nyrearterie	☐☐☐	☐☐☐

Forkalkninger i karveggen Ja ☐ Nei ☐

Aneurysme

Ja ☐ Nei ☐ Aneurysme lengde ☐☐☐ Veggtykkelse ☐

Avstand nyrearterie-aneurysme ☐☐☐

Iliaca communis

	Transversal mål	Anterioposterior mål	Lengde visualisert
Venstre a. iliaca communis	☐☐☐	☐☐☐	☐☐☐
Høyre a. iliaca communis	☐☐☐	☐☐☐	☐☐☐

Hø femoralarterie

✓ Ytre diameter ☐☐,☐ Lumen diameter ☐☐,☐

Pulsvariasjon Ja ☐ Nei ☐

Komprimerbarhet Ja ☐ Nei ☐

Henvises

Aorta ☐ Annet ☐ Hva? _____

OSLO GRAFISK AS, TRONDHEIM

HELSEUNDERSØKELSEN I TROMSØ
Institutt for Samfunnsmedisin
Universitetet i Tromsø
Tlf 77 64 48 16

Kjære

INVITASJON TIL EKSTRA UNDERSØKELSE AV HOVEDPULSÅREN

Vi viser til telefonsamtalen. Som nevnt benytter Helseundersøkelsen i Tromsø en ny metode (ultralyd) for å undersøke om det er utposning av hovedpulsåren i magen. Hos deg ble det ikke funnet tegn til utposning.

For å forsikre oss om at at ingen utposninger oversees med ultralyd, inviteres noen til en ekstra undersøkelse med CT-røntgen. Dette er en spesialundersøkelse som gir en mer nøyaktig beskrivelse av magen og hovedpulsåren. Deltakelse er frivillig og gratis.

Undersøkelsen tar 15-20 minutter og foregår med et spesielt røntgenapparat. Du merker ikke at bildene tas og det er ingen kjente bivirkninger. Røntgenstrålingen er lav og ufarlig. Undersøkelsen tilbys likevel ikke til kvinner som er gravid eller kan være gravid.

Opplysningene vi får ved undersøkelsen vil bli behandlet strengt konfidensielt og vil bare bli benyttet i vitenskapelige studier, eller om mulig for diagnose av sykdom hos deg.

Undersøkelsen foregår ved røntgenavdelingen, Regionsykehuset i Tromsø (RiTø), plan 6. Benytt hovedinngangen.

Du har fått time

Vi ber deg vennligst ta med dette brevet når du kommer.

Jeg har lest orienteringen og ønsker å delta

Dato ..... Navn .....

Vel møtt!

Pasientinformasjon

CT-undersøkelse av hovedpulsåren i magen

Ved ultralydundersøkelse av hovedpulsåren i magen viser det seg at den hos deg er noe videre enn forventet.

For at vi i framtiden bedre skal kunne måle og vurdere disse avvikelser inviteres du nå til ytterligere en undersøkelse av pulsåren med datatomografi (CT).

Denne undersøkelsen tar ca. 1 time. Den foregår slik at du legger deg på et spesielt røntgenapparat; CT, med den tas et antall bilder av din mage og hovedpulsåren.

Av selve bildetakingen merker du ingen ubehag. Røntgenstrålningen ved CT-undersøkelsen er 2-3 rad. Denne stråledose er i din alder ufarlig.

Under bildetakingen må det injeseres et røntgenkonstrastmiddel i en blodåre på armen. Dette er en slags "farge" som vises på bildet og medfører at din hovedpulsåre kan sees og måles.

Ved denne injeksjonen kan det i noen enkelte tilfeller oppstå varmefølelse og kvalme.

I meget sjeldne tilfeller kan elveblest og vanskeligheter med pusten oppstå. Vi kommer til å spørre om du har nyresykdom, alvorlig hjertesykdom, diabetes (sukkersyke) eller allergi. Dersom du har noen av disse sykdommene vil vi ikke tilby denne undersøkelsen.

Opplysningene vi får ved denne undersøkelse vil bli behandlet strengt konfidensielt og bare benyttes til vitenskapelige studier, eller om mulig for diagnose av sykdom hos deg.

Din deltakelse i denne undersøkelse er helt og absolutt frivillig, og du kan på et hvilket som helst punkt trekke deg ut og si nei til fortsatt deltakelse.

Jeg har lest og forstått ovenstående og gir herved mitt samtykke til å delta i CT-undersøkelse av hovedpulsåren.

Dato: ..... Navn: .....

SPESIALUNDERSØKELSEN '94-95

CT-UNDERSØKELSE AV BUKAORTA

Klientens initialer ☐☐☐

Undersøker ☐☐

Aorta

	Transversal mål	Anterioposterior mål
Nyrearterienivå	☐☐☐	☐☐☐
1 cm proximalt for nyrearterie	☐☐☐	☐☐☐
1 cm distalt for nyrearterie	☐☐☐	☐☐☐
Like før bifurkatur	☐☐☐	☐☐☐
Maksimal-mål distalt for nyrearterie	☐☐☐	☐☐☐

Forkalkninger i karveggen Ja ☐ Nei ☐

Aneurysme

Ja ☐ Nei ☐ Aneurysme lengde ☐☐☐ Veggtykkelse ☐☐

Avstand nyrearterie-aneurysme ☐☐☐ Avstand aneurysme-bifurkatur ☐☐☐

Iliaca communis

	Transversal mål	Anterioposterior mål	Lengde visualisert
Venstre a. iliaca communis	☐☐☐	☐☐☐	☐☐☐
Høyre a. iliaca communis	☐☐☐	☐☐☐	☐☐☐

Henvises

Aorta ☐ Annet ☐ Hva? _____

APPENDIX C

Tables 1 and 2

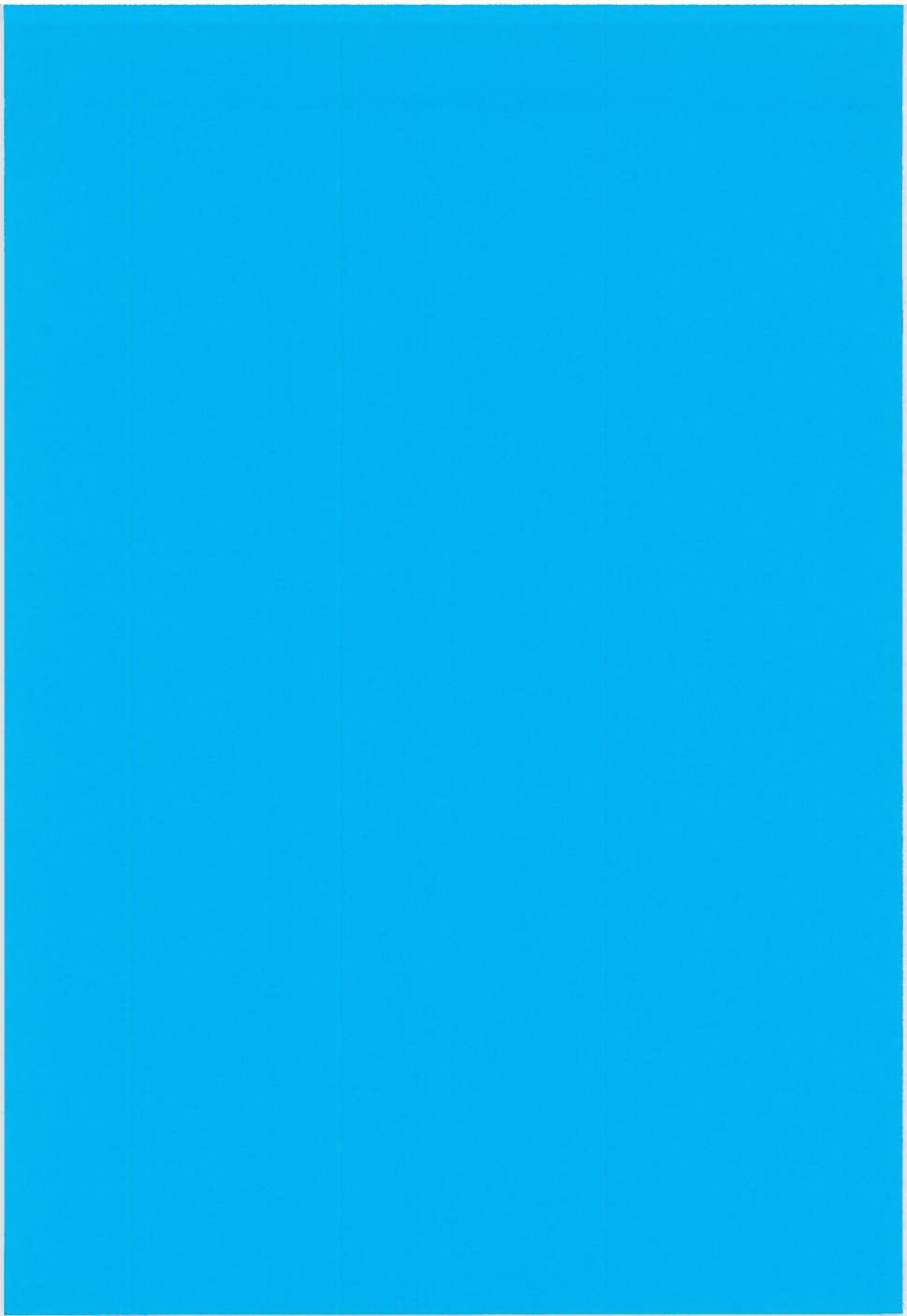


TABLE 1: Percentiles and some descriptive measures of maximal infrarenal aortic diameter in the anterior-posterior plane (mm) measured with ultrasound by sex and age. The Tromsø study 1994-95.

	Age (years)													
	25-34		35-44		45-54		55-64		65-74		75-84		Total	
	male	female	male	female	male	female	male	female	male	female	male	female	male	female
No. of subjects*	99	114	115	168	156	199	1394	1477	1117	1370	81	96	2962	3424
Percentiles														
2.5	15	13	16	14	17	15	17	15	17	15	18	15	17	14
5.0	15	13	17	14	18	15	18	15	18	16	18	15	17	15
10	16	14	17	15	18	16	19	16	19	16	19	16	18	16
25	17	15	18	16	19	17	20	18	20	18	21	18	20	17
50 (Median)	18	16	20	17	21	18	22	19	22	19	23	19	22	19
75	19	17	21	18	22	20	23	20	24	21	28	21	23	20
90	20	18	22	19	23	20	25	22	29	23	36	24	27	22
95	22	19	23	19	24	21	28	23	35	25	41	25	31	24
97.5	22	20	23	20	26	22	31	24	42	29	45	30	37	26
Mean	18.1	16.2	19.7	16.9	21.0	18.1	22.1	19.1	23.7	19.8	25.2	19.8	22.5	19.1
Standard deviation	1.9	1.7	1.8	1.7	2.4	1.9	3.9	2.6	6.9	3.9	7.6	4.0	5.4	3.3
Skewness	0.6	0.1	-0.1	-0.3	0.9	0.3	3.3	1.4	3.8	4.5	2.2	2.9	4.1	3.8

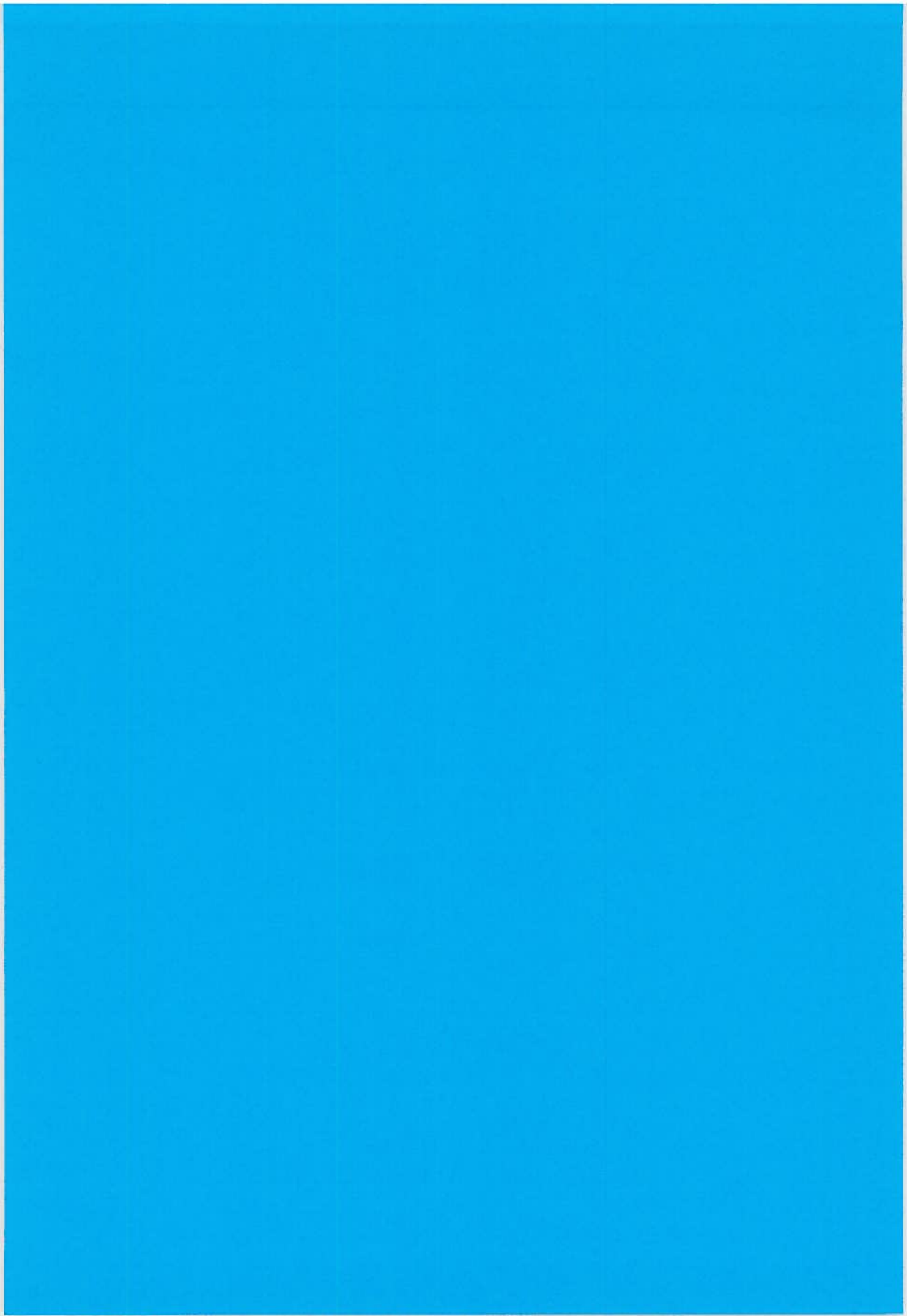
*Number of subjects.

Table 2: Time since smoking cessation and risk of abdominal aortic aneurysm. The Tromsø study 1994-95.

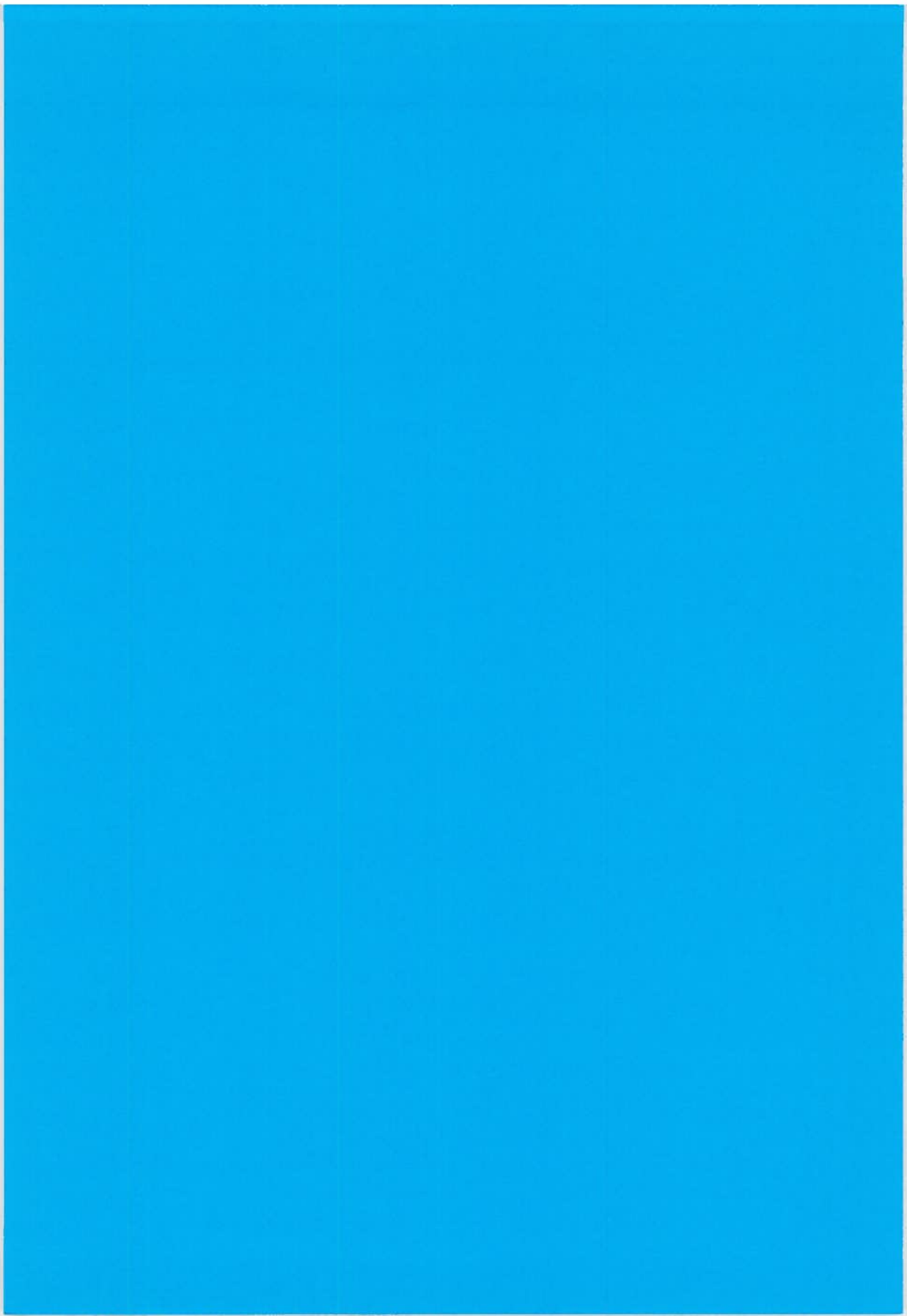
	Men				Women			
	n examined (% with AAA)	Age-adjusted OR (95% CI)*	Adjusted for duration† OR (95% CI)	Multivariate-adjusted‡ OR (95% CI)	n examined (% with AAA)	Age-adjusted OR (95% CI)	Adjusted for duration OR (95% CI)	Multivariate-adjusted OR (95% CI)
Never smokers	524 (1.9)	1.0	1.0	1.0	1447 (1.1)	1.0	1.0	1.0
Current smokers	987 (13.1)	7.37 (3.82-14.23)	1.13 (0.40,3.19)	1.50 (0.51,4.38)	1055 (4.2)	6.09 (3.36-11.02)	1.06 (0.27,4.15)	1.12 (0.25,4.91)
Time since smoking cessation:								
1-9 years	419 (12.9)	6.65 (3.32-13.31)	1.25 (0.46,3.40)	1.52 (0.54,4.28)	332 (1.8)	2.23 (0.85,5.83)	0.63 (0.15,2.63)	0.41 (0.08,2.13)
10-19 years	333 (11.4)	5.28 (2.57-10.82)	1.44 (0.57,3.57)	1.54 (0.60,3.94)	210 (2.4)	2.20 (0.79,6.15)	0.69 (0.18,2.60)	0.81 (0.20,3.31)
>19 years	675 (4.6)	1.74 (0.84-3.61)	0.77 (0.34,1.75)	0.86 (0.38,1.99)	336 (0.9)	0.81 (0.23,2.81)	0.38 (0.09,1.49)	0.44 (0.11,1.78)
Total	2938 (8.9)				3380 (2.2)			

*OR= Odds ratio (95% Confidence limits).
†Adjusted for age and duration of smoking.
‡Adjusted for age, duration of smoking, waist-hip ratio, systolic blood pressure, total serum cholesterol, serum HDL cholesterol, plasma fibrinogen, blood platelet count and use of antihypertensive medication

PAPERS I-V



PAPER I



Eur J Vasc Endovasc Surg 15, 497–504 (1998)

Intra- and Interobserver Variability in Ultrasound Measurements of Abdominal Aortic Diameter. The Tromsø Study*

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Objectives: *To assess the variability of ultrasonographic measurements at different levels of the abdominal aorta.*
Design: *Reproducibility study as part of a population health screening for abdominal aortic aneurysm.*
Materials and methods: *In 1994/1995 a total of 6892 subjects underwent ultrasound examination of the abdominal aorta. Variability of measurements was assessed in the beginning and end of the survey period by inviting 112 randomly selected participants to a second ultrasound scan within 3 weeks of the first scan. The subjects were examined by an experienced radiologist and three sonographers who had been given a short course in ultrasonography. All examiners were blinded to each other's results.*
Results: *Variability was similar in the beginning and end of the survey period. Both the intra- and interobserver variability were less than 4 mm for all sonographers in measurements of maximal infrarenal aortic diameter, and variability was similar for measurements in the anterior–posterior and transverse plane. Variability was greater for measurements at the renal level than aortic bifurcation level. The radiologist had lower variability than the other sonographers.*
Conclusion: *Ultrasound measurements of the maximal diameter can be obtained with a high degree of accuracy. Inexperienced sonographers may achieve acceptable performance given appropriate training and surveillance.*

Key Words: Abdominal aorta, ultrasonography; Aneurysm, aortic; Diagnostic radiology; Observer performance.

Introduction

The incidence of abdominal aortic aneurysms is probably increasing,[1,2] and mass screening with ultrasound has been suggested as a means to reduce the high mortality of this condition.[3–6] There is an increasing need for the follow-up and monitoring of small aneurysms as more new cases are detected with ultrasound and computed tomography. How well these objectives are achieved will depend on the accuracy of the ultrasound measurements of the aortic diameter.

The accuracy of ultrasound depends on the experience of the sonographer, the patients (e.g. fat, bowel gas, aortic tortuosity) and the quality of the ultrasound machine. The literature on the variability of ultrasound measurements of aortic diameter is limited. We know of only one report where the intra- and the interobserver variability have been analysed together in the same population.[7] The published estimates on interobserver variability are mostly based on examinations of selected patients with known or suspected aneurysms, and the results are inconsistent with estimates of the minimum resolvable change in maximal aortic diameter, which range between 2.2 and 10 mm.[7–12]

The maximal infrarenal aortic diameter compared to the diameter at the renal level has been suggested as a more reliable and important index than the maximal diameter alone.[3] If so, it is necessary to know the accuracy of the measurements of the diameter at different levels of the abdominal aorta. The variability of ultrasonographic measurements within the setting of a population screening programme has not been studied thoroughly. We therefore addressed these questions during the screening of more than 6800 persons participating in a population health screening programme in Tromsø, Norway, during 1994–1995.

Materials and Methods

Study design and measurements

The Tromsø study was started in 1974 and is a single-centre population-based prospective study of inhabitants in the municipality of Tromsø, Norway. The

* Part of this study was presented as a poster at RSNA 1995, poster 118.

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1078–5884/98/060497+08 $12.00/0

aims of the study are to investigate, by means of epidemiological, clinical and basic research, determinants of chronic diseases in order to assess aetiological significance, and to investigate potentially modifiable causes that may be developed into preventative or therapeutic strategies. The main focus is on cardiovascular diseases. The study design includes repeated population health surveys to which total birth cohorts and random samples are invited.

The fourth cross-sectional survey of the Tromsø population started in September 1994 and was completed in October 1995. The survey was conducted by the University of Tromsø in cooperation with the National Health Screening Service, and comprised two screening visits with an interval of 4–12 weeks. All inhabitants older than 24 years were invited to the first visit, and 27 161 subjects, 78% of the eligible population, participated. A protocol similar to that used during the previous surveys in this population[13] was followed. The examination included standardised measurements of height, weight, blood pressure, non-fasting serum lipids, serum calcium, gamma glutamyltransferase, haemoglobin and blood cell counts, and a 20 s electrocardiography (ECG) of lead I. Two questionnaires covered previous and present diseases and symptoms, use of drugs, lifestyle (physical activity, smoking, alcohol intake) and dietary habits, and socioeconomic situation. All subjects aged 55–74 years and random 5–10% samples of the other five-year age-groups were invited to the second visit. A total of 6892 subjects, 98% of those who came to the first visit and were eligible for the second visit, attended. The second visit comprised ultrasonographic measurements of aortic diameters, ultrasonography of the carotid artery, echocardiography, a 12-lead resting ECG, a 90 s rhythm ECG during standardised deep breathing, measurements of bone density, body fat composition, waist and hip circumference, blood pressure in sitting and standing position, and urine and blood sampling.

The reproducibility study

The reproducibility study was designed to study variability in aortic measurements between sonographers (different sonographers on the same occasion) and within sonographers (same sonographer on two separate occasions) in the beginning (week 10 and 11; first reproducibility study) and at the end (week 37 and 40; second reproducibility study) of the survey period. Eighty randomly selected subjects were invited to participate in the first reproducibility study. In all 79 individuals attended in week 10 and 76 attended in week 11. Forty randomly selected subjects were invited to the second part of the reproducibility study. Thirty-three subjects attended in week 37 and 29 attended in week 40.

The sonography and measurements of the abdominal aortas were performed by four examiners: A, a registered nurse, B, an assistant nurse, C, an experienced radiologist with special interest in vascular radiology and D, a radiographer. A, B and C had no experience or education in ultrasound prior to this project. The nurses were well experienced in nursing cardiovascular patients. Before starting this study the nurses were given a 40 h course over 2 weeks. This consisted of anatomy and pathology of the abdominal aorta, handling of the ultrasound machine and the probes, in addition to practical examination with instruction. Further, surveillance by the radiologist (C) were given during the first 2 months of this study during which time they performed approximately 400 examinations each. The radiographer had a similar training for about 60 h by the radiologist (sonographer C) before performing routine examinations in the study.

In the first part of the reproducibility study, all participants were examined with ultrasound by the nurse (sonographer A), the assistant nurse (sonographer B) and the radiologist (sonographer C). During the second reproducibility period, the radiographer (sonographer D) also examined the participants. All the sonographers were blinded to each other's results and the results from the previous week.

The subjects were examined in the supine position and/or in the left decubitus position when necessary. No instructions on food or fluid intake were given prior to the examination. The examination was carried out with a 3.5 MHz sector probe (Acuson 128-XP). The abdominal aorta was first visualised in the longitudinal plane and examined from diaphragm to bifurcation. The aorta was then examined in the axial plane with scans perpendicular to the longitudinal plane. Aortic diameters were measured at the renal artery level, 1 cm distal to this level and at the bifurcation level. In addition, maximal infrarenal aortic diameter was measured. Aortic diameter at the renal level was measured at the origin of the right main renal artery or at the origin of the left main renal artery when the right one was absent or not visualised. Both transverse and anterior–posterior diameters were measured. The diameter was measured with electronic calipers from the leading edge of the near wall to the leading edge of the far wall in the anterior–posterior plane and from the right leading edge to the left leading edge (external diameter) in the transversal plane. All the measurements were made on-line on images that were frozen in systole.

Statistical Analysis

Intra- and interobserver variations were estimated by calculating the mean (95% confidence interval (CI)) arithmetic difference between repeated measurements on the same subject. Variability was calculated as twice the standard deviation (S.D.) of the mean arithmetic difference according to Bland and Altman.[14,15] Given the sample size in the present study, 2 S.D. corresponds closely to the value obtained by calculating the repeatability coefficient according to the British Standards Institution.[16] If the differences are normally distributed, 95% of the differences will lie within a range of ± 2 S.D. of the mean difference. This range will be referred to as the limits of agreement.[14] To examine whether measurement variability was of the same magnitude when measuring both small and large aortic diameters, we plotted the arithmetic difference between repeated measurements against their average using data from the first reproducibility period. We also estimated variability by calculating the mean absolute difference between repeated measurements, and the percentage of the absolute differences 2 mm or less, 3 mm or less and 4 mm or less. Confidence intervals for percentages (p) were calculated with the formula: $CI = p \pm (1.96 \times \sqrt{p(100-p)/n})$. Two-sided p values less than 0.05 were considered to indicate statistical significance. The SAS software package was used.[17]

Results

A total of 112 individuals (48% men) participated in the reproducibility study at the beginning and end of the survey period. The results were similar in the two studies and we therefore present pooled data. The mean (S.D.) age of subjects was 58 (10.7) years, 26% were smokers and the mean body mass index was 25.7 (3.8) kg/m^2. The maximal infrarenal aortic diameter could be measured in 98% of the individuals. At the renal level, aortic measurements were obtained in 90–96% of participants, depending on the sonographer. The mean aortic diameter in the anterior–posterior plane at the renal level, 1 cm below the renal level and the bifurcation level was 20.4 (2.7) mm, 19.5 (2.7) mm and 17.6 (2.5) mm, respectively. The mean maximal infrarenal aortic diameter in the anterior–posterior plane was 19.8 (3.3) mm. The mean aortic diameter in the transversal plane at the renal level, 1 cm below the renal level and the bifurcation level was 21.8 (2.6) mm, 20.7 (2.6) mm and 18.5 (2.5) mm, respectively. The mean maximal infrarenal aortic diameter in the transversal plane was 21.1 (3.2) mm.

Intraobserver reproducibility

The mean arithmetic differences (defined as the value obtained on the first occasion minus the value obtained on the second occasion 1–3 weeks later) between the repeated measurements on the same subject by the same sonographer were generally small, although some of them were statistically significant (Table 1). Most of the differences were negative, indicating that the aortic diameters were measured slightly greater on the second compared to the first occasion. The differences were similar at the renal level, 1 cm below the renal level, bifurcation level and at the level of the maximal aortic diameter. The differences were also similar for all four sonographers.

Measurement variability, as estimated by the mean absolute difference and 2 S.D. of the mean arithmetic difference, was smaller for the radiologist (sonographer C) than the other three sonographers (sonographers A, B and D), and the radiographer (sonographer D) had less variability than the nurse and the assistant nurse (sonographers A and B) (Table 1). Variability tended to be larger at the renal and 1 cm below the renal level than at the bifurcation level, particularly for the less experienced sonographers, indicating that the estimate of aortic size is less accurate at the more proximal levels. Measurement variability was reasonably constant throughout the range of measurements (Fig. 1). Notably, intraobserver variability was similar for anterior–posterior and transverse measurements. For maximal aortic diameter in the anterior–posterior plane, the absolute intraobserver difference was 2 mm or less in 82 (95% CI; 78–86)%, 3 mm or less in 93 (90–96)% and 4 mm or less in 97 (95–99)% of cases (Table 3).

Interobserver reproducibility

The interobserver differences were generally small and non-significant or of borderline significance for most pairs of observers (Table 2). There was, however, one pair of sonographers (A vs. D) whose measurements in the anterior–posterior plane showed a marked difference, and another pair of sonographers (C vs. D) whose measurements in the transverse plane differed significantly, indicating the presence of "observer bias". Interobserver differences were similar in the anterior–posterior and the transverse plane.

Interobserver variability was of the same magnitude when measuring small and large aortic diameters (Fig. 2), but was greater at the renal level than at the bifurcation level for measurements in both planes

Table 1. Intraobserver differences and variabilities in ultrasonographic measurements of anterior–posterior (AP) and transverse plane (TR) aortic diameter at the renal level, 1 cm below the renal level, bifurcation and the maximal infrarenal level. The Tromsø Study.

		Renal level			1 cm below renal level			Bifurcation level			Maximal infrarenal level		
Sonographer[1]/ measurement plane	n[2]	Arithmetic difference Mean (95% CI)	Absolute difference Mean (s.d.)	Variability[3]	Arithmetic difference Mean (95% CI)	Absolute difference Mean (s.d.)	Variability[3]	Arithmetic difference Mean (95% CI)	Absolute difference Mean (s.d.)	Variability[3]	Arithmetic difference Mean (95% CI)	Absolute difference Mean (s.d.)	Variability[3]
							mm						
Sonographer A	99												
AP		−0.8 (−1.4, −0.2)	2.1 (1.8)	5.4	−0.7 (−1.1, −0.3)	1.6 (1.5)	4.2	−0.7 (−1.0, −0.4)	1.4 (1.2)	3.4	−0.6 (−1.0, −0.2)	1.6 (1.4)	4.0
TR		−1.0 (−1.6, −0.4)	2.3 (1.9)	5.6	−1.0 (−1.4, −0.6)	1.8 (1.4)	4.2	−0.6 (−1.0, −0.2)	1.7 (1.5)	4.2	−0.9 (−1.3, −0.5)	1.7 (1.4)	4.0
Sonographer B	88												
AP		0.2 (−0.3, 0.7)	1.6 (1.5)	4.4	−0.0 (−0.5, 0.5)	1.6 (1.4)	4.4	−0.2 (0.6, 0.2)	1.3 (1.1)	3.4	−0.1 (−.0.5, 0.3)	1.5 (1.3)	4.0
TR		−0.2 (−0.7, 0.3)	1.6 (1.3)	4.2	−0.2 (−0.7, 0.3)	1.7 (1.6)	4.6	−0.2 (−0.6, 0.2)	1.3 (1.1)	3.4	−0.2 (−0.7, 0.3)	1.7 (1.5)	4.0
Sonographer C	75												
AP		−0.3 (0.6, 0.0)	1.0 (0.9)	2.6	−0.5 (−0.8, −0.2)	1.0 (0.9)	2.6	0.3 (0.0, 0.6)	0.9 (0.8)	2.2	−0.7 (−1.0, −0.4)	1.2 (1.1)	3.0
TR		−0.2 (−0.5, 0.1)	1.1 (0.9)	2.8	−0.4 (−0.7, −0.1)	1.1 (1.0)	2.8	0.2 (−0.1, 0.5)	1.1 (0.8)	2.6	−0.5 (−0.8, −0.2)	1.2 (1.0)	3.0
Sonographer D	26												
AP		−0.7 (−1.3, −0.1)	1.4 (1.0)	3.0	−0.7 (−1.4, 0.0)	1.3 (1.2)	3.4	−0.5 (−1.1, 0.1)	1.2 (1.0)	3.0	−0.8 (−1.5, −0.1)	1.4 (1.2)	3.4
TR		−0.5 (−1.2, 0.2)	1.2 (1.1)	3.2	−0.5 (−1.1, 0.1)	1.3 (0.7)	2.8	−0.1 (−0.8, 0.6)	1.2 (1.1)	3.4	−0.7 (−1.3, −0.1)	1.4 (1.0)	3.2

AP: anterior–posterior aortic diameter; TR: transverse plane aortic diameter.
[1] Sonographer A, nurse; sonographer B, assistant nurse; sonographer C, radiologist; sonographer D, radiographer.
[2] n is given for measurement at the maximal infrarenal level; n is about 12% lower for renal and 1 cm below renal level measurements.
[3] Calculated as 2 s.d. of the mean arithmetic difference according to Bland and Altman.[14]

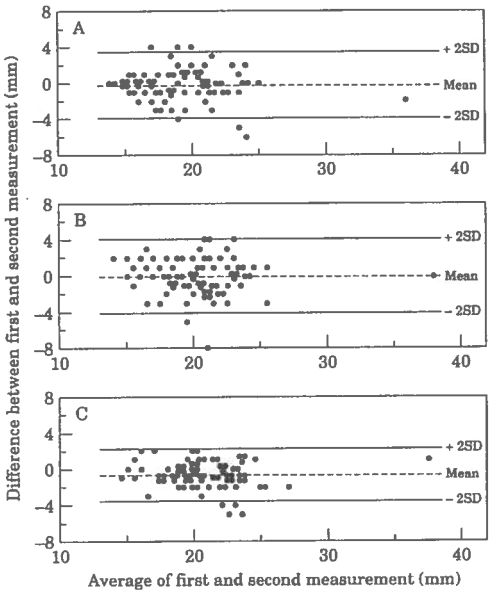

Fig. 1. Plots of difference against the average of maximal anterior–posterior infrarenal aortic diameter measured by the same sonographer on two separate occasions, with mean arithmetic difference (broken lines) and 2 s.d. (95% limits of agreement) (solid lines). Panel A, nurse; panel B, assistant nurse; panel C, radiologist. Data from the first reproducibility study (see Materials and Methods).

(Table 3). The variability was similar for measurements in the anterior–posterior and the transverse plane. For maximal aortic diameter in the anterior–posterior plane the absolute interobserver difference was 2 mm or less in 75 (95% CI; 70–80)%, 3 mm or less in 88 (85–91)% and 4 mm or less in 96 (94 to 98)% of cases (Table 3). Interestingly, interobserver variability and intraobserver variability was quite similar (Tables 1–3).

Discussion

The aim of the present study was to examine the performance of ultrasound within the setting of a population survey. We found that 96–97% of the measurements of maximal aortic diameter had a difference which was 4 mm or less. Further, 88–93% of these measurements differed with 3 mm or less. Our results are similar to those reported by Jaakola *et al.*[12] Among the randomly selected participants only one had an aneurysmal aorta (Figs 1 and 2). Therefore, the conclusions from the present study may not necessarily be applied to a clinical practice where most cases have abnormal aortas. Jaakola *et al.* recently showed that ultrasound variability was somewhat greater for aneurysmal aortas compared to normal aortas.[12] Also, the interobserver variability reported herein was attained in a research setting and may be difficult to duplicate in routine practice.

Other studies have examined selected patients with known or suspected aneurysmal aortas, and have provided data on interobserver variability of the ultrasound method for assessment of the maximal aortic diameter.[7–11] For maximum aortic diameter in the anterior–posterior plane, the coefficients of repeatability have been reported to be 3.0–7.5 mm,[7] 5.8–7.0 mm,[11] 2.2 mm,[10] and 5.8 mm.[12] The corresponding coefficient of repeatability in the present study ranged between 2.6 and 4.4 mm (Table 2). Several studies reported that interobserver variability was larger for the transverse measurements: 10–15 mm,[7] 10.3–16.0 mm[11] and 5.3 mm.[10] However, this phenomenon was not observed in a recent study by Jaakola *et al.*,[12] and in our study the corresponding coefficient ranged between 2.8 and 4.4 mm which was similar to what we observed for measurements in the anterior–posterior plane. It was previously suggested that the difference between the two planes was due to the superior axial resolution of the sonographic beam compared with its lateral (i.e. transverse) resolution.[8] Our data may indicate that the lateral resolution is sufficient with later generations of ultrasound equipment to allow precise measurements of transverse aortic diameter.

For mass screening purposes it may not always be possible or desirable to engage experienced radiologists as a sonographer. Our data indicate that other health personnel, after a relatively short period of training, may be able to measure the maximal aortic diameter within ± 4 mm of the "true" diameter, whereas the corresponding value for an experienced radiologist is ± 3 mm. Hence, the lower limit for referral should be 26–27 mm if the purpose of the survey is to identify all subjects with an abdominal aorta greater than 30 mm. In our study population 26 mm corresponds to the 90th and 97.5th percentile for maximal anterior–posterior diameter in men and women, respectively, implying that about 10% of men and 2.5% of women who were screened would be referred for a second ultrasound and/or CT examination to determine the aortic diameter more precisely.

Ultrasound has been recommended in population screening to detect abdominal aortic aneurysms. Mass screening should be based on a test which is sensitive, accurate, reproducible and can be carried out by different examinators. Furthermore, the definition of a condition or disease should be based on a limited

Table 2. Interobserver differences and variabilities in ultrasonographic measurements of anterior–posterior (AP) and transverse plane (TR) aortic diameter at the renal level, 1 cm below the renal level, bifurcation and the maximal infrarenal level. The Tromsø Study.

Sonographer pair[1]/ measurement plane	n[2]	Renal level: Arithmetic difference Mean (95% CI)	Renal level: Absolute difference Mean (s.d.)	Renal level: Variability[3]	1 cm below renal level: Arithmetic difference Mean (95% CI)	1 cm below renal level: Absolute difference Mean (s.d.)	1 cm below renal level: Variability[3]	Bifurcation level: Arithmetic difference Mean (95% CI)	Bifurcation level: Absolute difference Mean (s.d.)	Bifurcation level: Variability[3]	Maximal infrarenal level: Arithmetic difference Mean (95% CI)	Maximal infrarenal level: Absolute difference Mean (s.d.)	Maximal infrarenal level: Variability[3]
							mm						
Sonographer A vs. B	106												
AP		−0.1 (−0.6, 0.4)	2.1 (1.6)	5.2	−1.7 (−2.1, −1.3)	2.1 (1.7)	4.2	−0.7 (−1.1, 0.3)	1.7 (1.4)	4.0	−1.5 (−1.9, −1.1)	2.1 (1.7)	4.4
TR		1.0 (0.5, 1.5)	2.0 (1.8)	5.0	−1.0 (−1.5, −0.5)	2.0 (1.5)	4.6	−0.0 (−0.5, 0.5)	1.7 (1.4)	4.6	−0.9 (−1.3, −0.5)	1.9 (1.4)	4.4
Sonographer A vs. C	77												
AP		−0.2 (−0.8, 0.4)	2.0 (1.2)	4.6	−0.9 (−1.4, −0.4)	1.7 (1.3)	3.8	−0.7 (−1.1, −0.3)	1.6 (1.1)	3.6	−1.1 (−1.5, −0.7)	1.6 (1.2)	3.4
TR		0.6 (0.0, 1.2)	1.9 (1.6)	4.8	−0.1 (−0.6, 0.4)	1.7 (1.4)	4.4	0.3 (−0.1, 0.7)	1.5 (1.2)	3.8	−0.3 (−0.7, 0.1)	1.4 (1.1)	3.6
Sonographer B vs. C	77												
AP		−0.5 (−1.1, −0.1)	1.7 (1.7)	4.6	0.3 (−0.3, 0.9)	1.6 (1.8)	4.8	−0.7 (−1.1, −0.3)	1.4 (1.0)	3.2	−0.0 (−0.4, 0.4)	1.4 (1.1)	3.6
TR		−0.8 (−1.4, −0.2)	2.0 (1.6)	5.0	0.4 (−0.3, 1.1)	1.8 (2.2)	5.6	−0.5 (−0.8, −0.2)	1.1 (1.0)	2.8	0.1 (−0.4, 0.6)	1.5 (1.3)	4.0
Sonographer A vs. D	30												
AP		−2.4 (−3.1, −1.7)	2.8 (1.5)	4.0	−2.4 (−3.0, −1.8)	2.6 (1.3)	3.0	−2.2 (−2.7, −1.7)	2.3 (1.4)	3.0	−2.4 (−3.0, −1.8)	2.6 (1.4)	3.2
TR		0.1 (−0.3, 0.5)	0.7 (0.8)	2.2	0.5 (−0.0, 1.0)	1.1 (0.9)	2.6	−0.4 (−1.0, 0.2)	1.2 (1.2)	3.4	0.6 (0.1, 1.1)	1.1 (0.9)	2.6
Sonographer B vs. D	30												
AP		−1.1 (−1.7, −0.5)	1.6 (1.1)	3.2	0.2 (−0.2, 0.6)	0.9 (0.7)	2.2	0.1 (−0.4, 0.6)	1.0 (0.8)	2.6	0.3 (−0.2, 0.8)	1.0 (0.9)	2.8
TR		−1.1 (−1.7, −0.5)	1.4 (1.2)	3.0	0.7 (−0.1, 1.5)	1.7 (1.2)	4.0	−0.5 (−1.0, −0.0)	1.1 (0.8)	2.6	0.6 (−0.1, 1.3)	1.7 (1.2)	4.0
Sonographer C vs. D	29												
AP		−0.5 (−0.9, −0.1)	0.9 (0.6)	2.0	0.4 (−0.1, 0.9)	1.1 (0.8)	2.6	−0.4 (−0.8, 0.0)	0.9 (0.8)	2.4	0.3 (−0.2, 0.8)	1.0 (0.8)	2.6
TR		−1.2 (−2.1, −0.3)	2.1 (1.6)	4.8	−1.6 (−2.3, −0.9)	2.0 (1.4)	3.6	−2.7 (−3.4, −2.0)	2.7 (1.7)	3.6	−1.6 (−2.3, −0.9)	1.9 (1.4)	3.6

AP: anterior–posterior aortic diameter; TR: transverse plane aortic diameter.
[1] Sonographer A, nurse; sonographer B, assistant nurse; sonographer C, radiologist; sonographer D, radiographer.
[2] n is given for measurement at the maximal infrarenal level; n is about 12% lower for renal and 1 cm below renal level measurements.
[3] Calculated as 2 s.d. of the mean arithmetic difference according to Bland and Altman.[14]

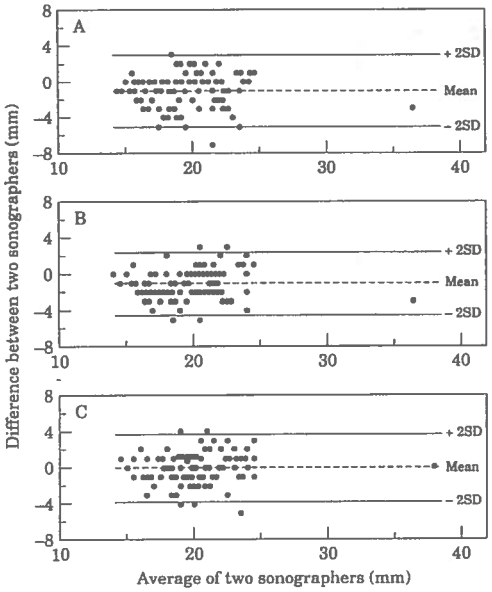

Fig. 2. Plots of difference against the average of maximal anterior–posterior infrarenal aortic diameter measured by two sonographers on the same occasion, with mean arithmetic difference (broken lines) and 2 s.d. (95% limits of agreement) (solid lines). Panel A, nurse vs. assistant nurse; panel B, nurse vs. radiologist; panel C, assistant nurse vs. radiologist. Data from the first reproducibility study (see Materials and Methods).

number of criteria and measurements with a high degree of accuracy. As the aorta at the renal level remains the most normal (not dilated) during lifetime, the diameter here has been suggested as an individual reference value.[3,18] However, the present study shows that ultrasound measurements at this level have greater intra- and interobserver variability than measurements at other levels of the aorta. This reduced accuracy is expected and may be due to obesity, bowel gas and difficulties in identifying the renal arteries. At the aortic birfurcation the aorta is more accessible, and this is reflected in low intra- and interobserver variability for the measurements at this level. In our study the intraobserver variability was lower for the radiologist than for other sonographers for measurements at all aortic levels and the differences were most pronounced for measurements at the renal level. The maximal aortic diameter is obviously the most important variable to be measured, since this measure is used to define whether an aneurysm is present or not. Our findings suggest that specificity may not be improved unless the measurements at the renal level are done by a highly experienced and skilled sonographer. For screening purposes the definition of abdominal aortic aneurysm should therefore probably be based on the maximal aortic diameter, since this definition may be more precise than a definition that requires measurements of diameter also at the renal level.

The present study shows that the minimum detectable change in maximal infrarenal aortic diameter ranged between 3 and 4 mm. Most aneurysms have a growth rate of less than 5 mm per year. A small aneurysm must increase the diameter by some centimetres before operation is considered. Such development takes several years. Thus, the accuracy of measurements demonstrated in the present study is fully satisfactory. We have shown that ultrasonographic measurements of the maximal abdominal aortic diameter can be obtained with an acceptable degree of accuracy. Measurement precision and variability is similar in the anterior–posterior and the transverse plane. Measurement variability is greater at the renal level than at the bifurcation level. Long-term experience with ultrasound is associated with low variability, but inexperienced sonographers may achieve acceptable performance given appropriate training and surveillance.

Acknowledgements

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Table 3. Percentages of inter- and intraobserver differences in measurement of the maximal infrarenal aortic diameter lying within specified limits. The Tromsø Study.

	Interobserver difference		Intraobserver difference	
Limit	Anterior–posterior plane	Transverse plane	Anterior–posterior plane	Transverse plane
2 mm or less	75 (70–80)	76 (71–80)	82 (78–86)	79 (75–84)
3 mm or less	88 (85–91)	93 (90–95)	93 (90–96)	92 (89–95)
4 mm or less	96 (94–98)	97 (96–99)	97 (95–99)	97 (95–99)

The values are percentages with 95% confidence limits in the parentheses.

References

1 Pleumeekers HJCM, Hoes AW, van der Does E, Van Urk H, Grobbee DE. Epidemiology of abdominal aortic aneurysms. *Eur J Vasc Surg* 1994; 8: 119–128.
2 Melton III LJ, Bickerstaff LK, Hollier LH, Van Peenen HJ, Lie JT, Pairolero PC, Cherry KJ, O'Fallon W. Changing incidence of abdominal aortic aneurysms: a population based study. *Am J Epidemiol* 1984; 120: 379–386.
3 Collin J, Araujo L, Walton J, Lindsell D. Oxford screening programme for abdominal aortic aneurysm in men aged 65 to 74 years. *Lancet* 1988; ii: 613–615.
4 Morris GE, Hubbard CS, Quick CR. An abdominal aortic aneurysm screening programme for all males over the age of 50 years. *Eur J Vasc Surg* 1994; 8: 156–160.
5 Ögren M, Bengtsson H, Bergqvist D, Ekberg O, Hedblad B, Janzon L. Prognosis in elderly men with screening detected abdominal aortic aneurysm. *Eur J Endovasc Surg* 1996; 11: 42–47.
6 van der Villet JA, Boll APM. Abdominal aortic aneurysm. *Lancet* 1997; 349: 863–866.
7 Ellis M, Powell JT, Greenhalgh RM. Limitations of ultrasonography in surveillance of small abdominal aortic aneurysms. *Br J Surg* 1991; 78: 614–616.
8 Yucel EK, Filmore DJ, Knox TA, Waltman AC. Sonographic measurement of abdominal aortic diameter: interobserver variability. *J Ultrasound Med* 1991; 10: 681–683.
9 Grimshaw GM, Docker MF. Accurate screening for abdominal aortic aneurysm. *Clin Phys Physiol Meas* 1992; 13: 135–138.
10 Akkersdijk GJM, Puylaert JBCM, Coerkamp EG, de Vries AC. Accuracy of ultrasonographic measurement of infrarenal abdominal aortic aneurysm. *Br J Surg* 1994; 81: 376.
11 Thomas PRS, Shaw JC, Ashton HA, Kay DN, Scott RAP. Accuracy of ultrasound in a screening programme for abdominal aortic aneurysms. *J Med Screen* 1994; 1: 3–6.
12 Jaakkola P, Hippeläinen M, Farin P, Rytkönen H, Kainulainen S, Partanen K. Interobserver variability in measuring the dimensions of the abdominal aorta: comparison of ultrasound and computed tomography. *Eur J Vasc Endovasc Surg* 1996; 12: 230–237.
13 Bønaa KH, Arnesen E. Association between heart rate and atherogenic blood lipid fractions in a population. The Tromsø study. *Circulation* 1992; 86: 394–405.
14 Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* 1986; i: 307–310.
15 Bland JM, Altman DG. Comparing methods of measurement; why plotting difference against standard method is misleading. *Lancet* 1995; 346: 1085–1087.
16 British Standards Institution. Precision of test methods I: guide for the determination and reproducibility for a standard test method (BS 5497, pat 1). London: BSI, 1979.
17 SAS Institute Inc. SAS/STAT™ User's Guide, Release 6.03 Edition, Cary, NC: SAS Institute Inc., 1988.
18 Anonymous. Suggested standards for reporting on arterial aneurysms. *J Vasc Surg* 1991; 13: 444–450.

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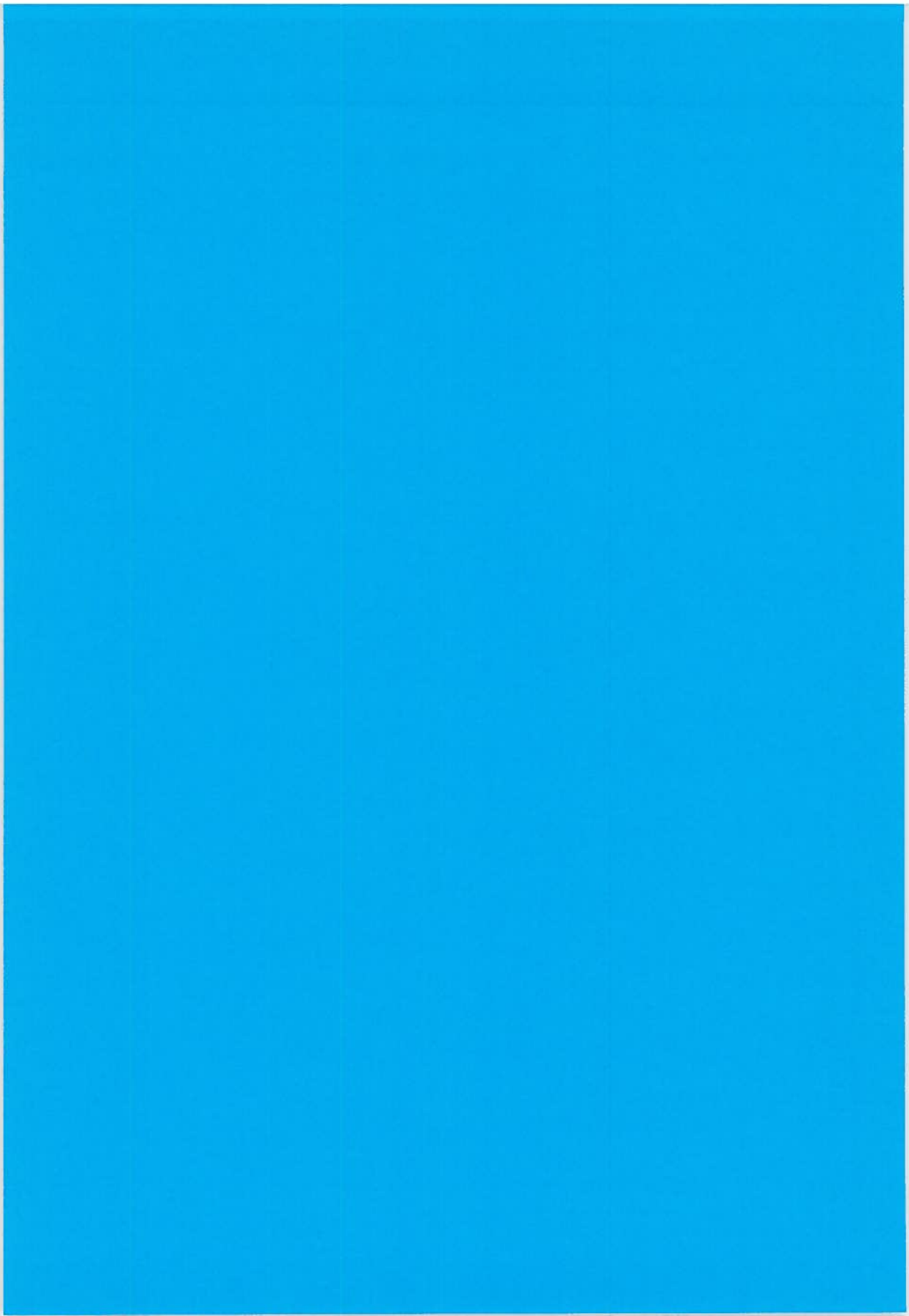
PAPER II



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Intra- and Interobserver Variability in the Measurements of Abdominal Aortic and Common Iliac Artery Diameter with Computed Tomography. The Tromsø study

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Objectives: *to assess intra- and interobserver variability in the measurement of aortic and common iliac artery diameter by means of computed tomography (CT).*
Design: *reproducibility study.*
Material and Methods: *three radiologists performed measurements of aortic diameter at five different levels and of both common iliac arteries with CT. Fifty-nine subjects were examined, 29 with and 30 without abdominal aortic aneurysms (AAA) as assessed by ultrasound.*
Results: *intraobserver variability varied between radiologists, measurement plane (anterior-posterior vs transverse) and measurement level. The interobserver variability was markedly higher at the bifurcation than at the suprarenal level and higher than intraobserver variability for measurements at all levels. Both intraobserver and interobserver variability increased with increasing vessel diameter and were largest in patients with AAA. The absolute intraobserver difference of the maximal infrarenal aortic diameter was 2 mm or less in 94% of intraobserver pairs. The corresponding interobserver difference was 82%.*
Conclusions: *interobserver variability of CT measurements of aortic and common iliac artery diameter is not negligible and should be taken into account when making clinical decisions. When assessing change in aortic diameter, previous CT-scans should be reviewed simultaneously as a routine to exclude interobserver variability.*

Key Words: Abdominal aortic aneurysms; Aortic diameter; Computed tomography; Measurement variability; Interobserver; Intraobserver.

Introduction

The use of ultrasound and computed tomography (CT) is central in the diagnosis and follow-up of patients with abdominal aortic aneurysms (AAA). As both the maximal AAA diameter and the growth inform treatment decisions, a high degree of reproducibility is essential.

Unlike for ultrasound,[1–8] few studies have evaluated the variability in CT determined aortic diameter.[1,9] Lederle *et al.*[9] reported intraobserver and interobserver variability in CT measurements in a large multi-centre based study of American veterans, and concluded that differences in measurement of 5 mm or more were common. Only aortas with maximal diameter between 40 and 55 mm were examined, however.[9] Jaakkola *et al.*[1] included 14 normal and 19 aneurysmal aortas in their study, and found that interobserver variability in the anterior-posterior plane was 3.7 and 3.1 mm for normal and aneurysmal aortas, respectively. The corresponding values in the transverse plane were 3.0 and 6.9 mm, respectively.

There is one published study investigating in detail the inter- and intraobserver variability of measurements of the upper neck of the aneurysm, the aneurysm and iliac arteries.[10] However, only 10 consecutive patients eligible for endovascular treatment were included. There is a need for more knowledge about the accuracy of the CT measurements.

The aim of this study was to examine the variability of CT measurements of aortic and common iliac artery diameter in subjects with normal and aneurysmatic aortas. The intraobserver and interobserver variability were assessed for three radiologists with a variable degree of experience, measuring the aorta and common iliac arteries of 59 individuals.

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Material and Methods

Study design

The Tromsø study was started in 1974 and is a population-based prospective study of inhabitants in the municipality of Tromsø, Norway.[11,12] In the fourth cross-sectional survey in 1994/95, all inhabitants older than 24 years were invited to the screening, and 27 159 subjects, 77% of the eligible population, participated. A protocol similar to that used during the previous surveys in this population[12] was followed. All subjects aged 55–74 years and 5–10% samples of the other five-year age groups under the age of 85 years, in addition to some small subgroups were invited to a second examination. This comprised *inter alia* ultrasonographic measurements of aortic diameters. A total of 6892 subjects, 79% of the eligible population had their aorta measured as previously described.[8,13] An aortic aneurysm was defined as present if one or more of the following criteria were met: (1) the aortic diameter at the renal level was equal to or greater than 35 mm in either anterior-posterior or transverse plane, (2) the infrarenal aortic diameter was $\geq$5 mm larger than renal aortic diameter in either plane, (3) a localised dilatation of the aorta was present.

The 348 subjects (79% men) who fulfilled these criteria and 287 representative subjects with ultrasonographically normal aortas were invited to the Department of Radiology for routine CT examination and measurements of the aortic and both common iliac artery diameters.

The computed tomography study

Three hundred and thirty-four men and women with ultrasonographically detected abdominal aortic aneurysm (96%) and 229 subjects with ultrasonographically normal aortas (80%) accepted the invitation. The CT examination was carried out with Siemens CT (Somatom HIQ Type 600 Serial no. 8349). The examination was done under continuous intravenous injection of contrast medium (120 ml omnipaque 300 mg iodine/ml) and with 10 mm slice thickness and 10 mm increment. The CT examination in subjects with normal aortas was done without intravenous contrast medium. The Regional Committee for Medical Research Ethics approved the study.

The abdominal aorta from the diaphragm to the bifurcation and both common iliac arteries were examined. All the CT examinations were stored in an optic disc and measurements were done on the screen using electronic callipers. The diameter was registered to the nearest millimetre. The external aortic diameter was measured in the anterior-posterior and transverse plane at the renal level, 1 cm suprarenal, 1 cm below the renal level, just before the bifurcation level and both common iliac artery diameters at their origin (Fig. 1). In addition, the maximal infrarenal diameter was measured. The aortic diameter measured 1 cm below the renal level was considered to represent the maximum infrarenal aortic diameter when the infrarenal aorta was normal and no slices in the infrarenal segment had larger diameter. The different aortic and iliac levels for measurement were decided by the individual participating radiologists on the available CT scans. Measurements of aortic and iliac diameters were made perpendicular to the direction of tortuosity in tortuous aortas and iliac arteries. This was done to correct for oblique slices due to tortuosity.

For this reproducibility study, we selected randomly 30 subjects of those with AAA and 30 subjects with normal aortas as assessed by ultrasound. Due to technical problems, data from one person with aortic aneurysm was not available for readings and another subject with graft-operated aorta was not read by two

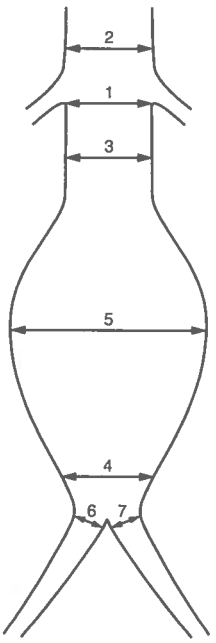

Fig. 1. The level of measurements on the axial images with ultrasound and computed tomography: (1) renal artery level; (2) suprarenal level; (3) 1 cm infrarenal level; (4) aortic bifurcation level; (5) maximal infrarenal level; (6) right common iliac artery level and (7) left common iliac artery level.

of the radiologists. There were also occasionally missing values of diameter at some levels. In order to evaluate intraobserver and interobserver variability in the measurements of the aortic and common iliac artery diameter, the CT examinations were read on the screen by three radiologists twice with at least three weeks interval. They had no access to the readings of each other and their own previous readings. One of the radiologists was an experienced vascular radiologist (A), one was an experienced vascular resident (B) and the third was an experienced neuroradiologist with limited experience from vascular radiology (C).

Statistical analysis

Intraobserver and interobserver differences were estimated by calculating the mean (and 95% confidence interval (CI)) of the arithmetic differences between repeated measurements on the same subject. Variability was calculated as 1.96 standard deviation (SD) of the mean arithmetic difference according to Bland and Altman.[14,15] If the differences are normally distributed, 95% of the differences will lie within a range of 1.96 SD of the mean difference. This range will be referred to as the limits of agreement.[14] To examine whether measurement variability was of the same magnitude when measuring both small and large diameters, we plotted the arithmetic differences between repeated measurements against the average diameter. We also estimated variability by calculating the mean absolute differences between repeated measurements, and the percentage of the absolute differences that were 2 mm or less, 3 mm or less and 4 mm or less.

The individual differences and means for measurements at all aortic and common iliac artery levels in both planes were pooled and analysed by analysis of variance in order to identify the effects of different readers, measurement plane, measurement level and presence of aneurysm. For interobserver differences, whether it was first or second reading was also included as a factor. Thus, data from CT measurements from the same person is included in the analysis many times. This was handled in the analysis by including person as a factor in the analysis of variance. Measurements of the neck of aneurysm (1 cm below the renal level) were excluded from analysis of variance due to interdependency with measurements of the maximal infrarenal aortic diameter. Separate subgroup analysis did not show any significant difference for measurement variability at this level. Two-sided p-values less than 0.05 were considered to indicate statistical significance. The SAS software package was used.[16]

Results

The characteristics of the study subjects are given in Table 1. In subjects with an aortic aneurysm, there was a predominance of smoking men with relatively high risk of cardiovascular disease. Five of the aortic aneurysms extended to the right common iliac and two to the left common iliac artery.

Intraobserver reproducibility

The mean arithmetic difference between the repeated measurements on the same subject by the same radiologist was generally small (mean −0.002 mm, 95% CI: −0.07, 0.07), although the differences were statistically significant between some subgroups (readers, measurement plane and presence of aneurysm)

Table 1. Descriptive characteristics of the subjects with and without abdominal aortic aneurysm participating in the reproducibility study.

	Subjects without aneurysm	Subjects with aneurysm	All
Number	30	29	59
Age (SD) (range) years	68.0 (5.5) (56–78)	66.8 (6.4) (55–77)	67.4 (5.9) (55–78)
Men %	47	76	61
Smokers %	33	62	47.5
Body-mass index kg/m^2	25.0 (3.4)	27.0 (4.2)	26.0 (3.9)
Serum HDL mmol/l	1.49 (0.41)	1.40 (0.36)	1.45 (0.38)
Serum cholesterol mmol/l	6.79 (1.03)	7.01 (1.40)	6.90 (1.22)
Ultrasound assessed maximal aortic diameter (SD) (range) mm			
Anterior-posterior plane	19.9 (2.5) (15–25)	34.0 (8.5) (25–63)	27.0 (9.5) (15–63)
Transverse plane	21.1 (2.9) (16–28)	36.0 (10.3) (25–77)	28.6 (10.7) (16–77)
Computed tomography assessed maximal aortic diameter (SD) (range) mm			
Anterior-posterior plane	22.9 (2.3) (19–28)	35.0 (8.9) (23–65)	28.9 (8.9) (19–65)
Transverse plane	22.5 (2.4) (17–26)	35.7 (10.2) (23–70)	29.1 (9.9) (17–77)

Table 2. Intraobserver differences and variability with computed tomography measurements of abdominal aortic and common iliac artery diameter. The Tromsø Study 1994–95.

	Number of pairs	Mean (mm) (95% CI)	*p* value	Variability (mm)*
All measurements	2086	−0.002 (−0.07, 0.07)		3.1
Reader			<0.001	
A	698	−0.21 (−0.31, −0.12)		2.6
B	692	0.01 (−0.10, 0.11)		2.8
C	696	0.20 (0.06, 0.34)		3.8
Measurement plane			<0.001	
Anterior-posterior	1043	−0.17 (−0.25, −0.08)		2.8
Transverse	1043	0.16 (0.06, 0.27)		3.3
Measurement level			0.06	
Aortic level				
Suprarenal	352	−0.15 (−0.28, −0.02)		2.5
Renal	352	0.06 (−0.14, 0.25)		3.6
Bifurcation	346	0.03 (−0.16, 0.21)		3.5
Maximal infrarenal	348	−0.11 (−0.27, 0.05)		3.0
Iliac artery level				
Right iliac artery	344	0.19 (0.02, 0.35)		3.1
Left iliac artery	344	−0.02 (−0.17, 0.14)		2.9
Measurement at				
All aortic levels	1398	−0.04 (−0.13, 0.04)	0.07	3.2
Both iliac artery levels	688	0.08 (−0.03, 0.20)		3.0
Ultrasound assessed aneurysm			0.01	
No	1060	0.08 (0.01, 0.16)		2.5
Yes	1026	−0.09 (−0.20, 0.02)		3.6

*Variability calculated as 1.96 SD of the mean difference.[14]

(Table 2). As adjustment for subject and the other factors included in the Table 2 did not influence the mean values, we present the mean differences without adjustment.

The mean arithmetic difference for one of the radiologists (A) was negative, indicating that diameters were measured slightly larger at the second compared to the first occasion. For the reader C, the opposite was the case.

The results indicate that the measurement variability, as estimated by 1.96 SD of the mean arithmetic difference (limits of agreement), was smaller for radiologist A (2.6 mm) and B (2.8 mm) than for radiologist C (3.8 mm), higher in the transverse plane (3.3 mm) than in the anterior-posterior plane (2.8 mm) and higher in aneurysmatic (3.6 mm) than in normal aortas (2.5 mm) (Table 2).

The variability was higher in all examined subgroups (readers, plane and levels) when measuring arteries with aneurysm compared to arteries without aneurysm (data not shown in the table). In particular, the variability for the maximal infrarenal diameter was 2.2 and 3.6 mm for normal and aneurysmatic aortas, respectively. Variability throughout the range of measurements is shown in Figure 2. The figure suggests an increased standard deviation of the differences with increasing diameter. However, in a linear model, the absolute difference increased with a modest 0.17 mm per 10 mm increased vessel diameter. This relationship was, however, only found for the transverse plane measurements (0.3 mm per 10 mm increase in diameter). Figure 3 illustrates that the three radiologists differ with regard to intraobserver variability.

In order to make our results comparable with previous research, we present some results for the maximal infrarenal aortic diameter only. The variability in the anterior-posterior plane was 1.6, 2.8 and 2.4 mm for radiologist A, B and C, respectively. The corresponding figures for the transverse plane were 2.9, 2.6 and 4.6 mm, respectively (data not shown).

Interobserver reproducibility

The mean interobserver difference was 0.48 (95% CI: 0.41, 0.55) mm. The interobserver differences varied significantly between different reader pairs, between first and second reading as well as between different aortic levels and both common iliac arteries ($p < 0.001$). The measurements by radiologist A were systematically slightly higher than those done by B and C, and B had systematically slightly lower measurements than C (Table 3). As adjustment for subject

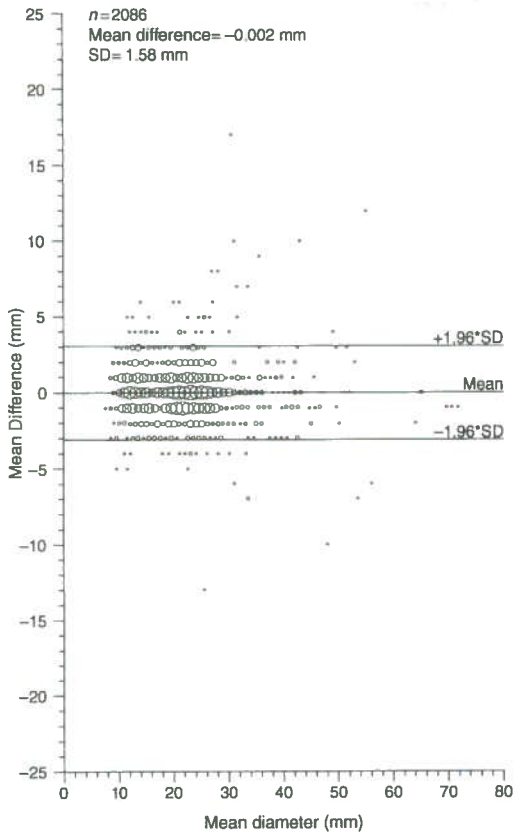

Fig. 2. Plots of intraobserver differences against the average diameter of aorta and common iliac arteries measured with computed tomography for individual radiologists.

and the other factors included in the Table 3 did not influence the mean values, we present mean differences without adjustment.

The interobserver measurement variability (1.96 SD) is given in the right column of Table 3. Mean variability was 4.5 mm. The variability was highest at the bifurcation level (6.6 mm) and lowest for measurement of left common iliac artery diameter (3.5 mm). As for intraobserver variability, the variability was higher for measurement of aortas with than without an aneurysm. This was the case for all the comparisons between readers, both first and second reading, measurement plane and level of the artery. For the maximal infrarenal diameter, the variabilities were 5.2 and 2.8 mm, respectively. The mean absolute difference increased 0.4 mm per 10 mm increase in the diameter of the blood vessel. This relationship was, however, significantly ($p < 0.001$) stronger in the transverse plane (0.57 mm per 10 mm increase in diameter) than in the anterior-posterior plane (0.21 mm per 10 mm increase in diameter). The interobserver differences as a function of diameter is displayed in Figure 4.

Absolute intraobserver and interobserver differences

The absolute intraobserver differences for measurements of the maximal infrarenal aortic diameter in the anterior-posterior plane were 2 mm or less in 96% and 3 mm or less in 99.4% of intraobserver pairs. Only 0.6% of the differences were 5 mm or more (Table 4). Radiologist A had all the readings within 2 mm, B had one difference larger than 3 mm, whereas C had all the differences within 3 mm. In the transverse plane, the absolute intraobserver differences were in general somewhat larger (Table 4). The absolute difference in maximal diameter in any plane was 2 mm or less and 5 mm or more in 93.7 and 2.9% of the pairs, respectively.

For measurements of maximal aortic diameter in the anterior-posterior plane, the absolute interobserver differences were 2 mm or less in 84.9%, 3 mm or less in 93.0%, and 4 mm or less in 97.1% of measurement pairs (Table 4). The interobserver differences were larger in the transverse plane. The absolute interobserver difference in maximal diameter in any plane was 2 mm or less and 5 mm or more in 82 and 6.1% of the pairs, respectively.

Discussion

Many patients with an AAA detected by ultrasound are imaged with CT and maximum aortic diameter as assessed with CT is considered the gold standard for clinical decision-making.

If an aneurysm is to be treated by stentgraft, the exact sizing of the graft is of great importance. Mismatch between the diameter of the body of the graft and the diameter of the upper neck of aneurysm may cause clinical complications. It is equally important to avoid mismatch in the distal anchoring of the bifurcated aorto-iliac stentgrafts by exact measurements of the common iliac artery diameters. Thus, the accuracy of the CT measurements of the abdominal aorta and common iliac arteries is important both for diagnosis, follow-up and in preoperative decision making for aneurysms.

This study was performed with conventional CT. Single and multislice spiral CT technology make it

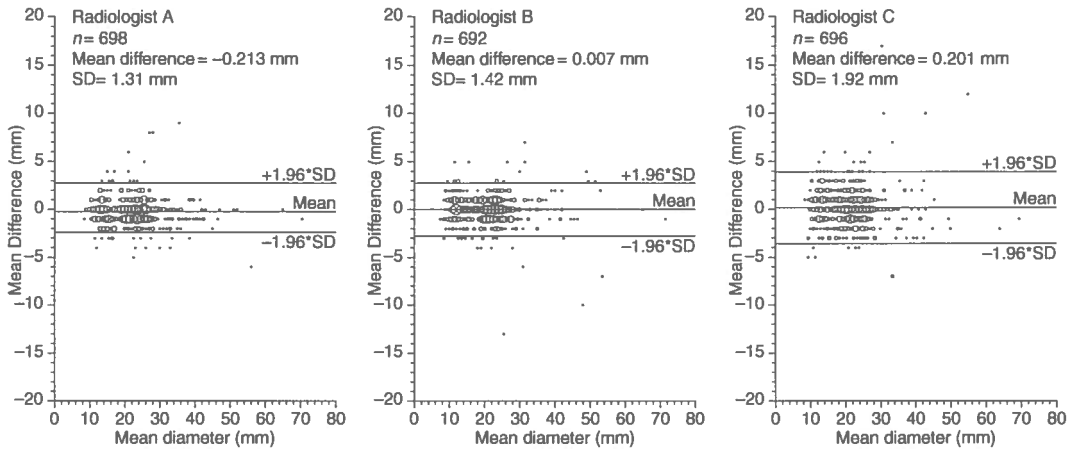

Fig. 3. Plot of intraobserver differences against the average diameter of aorta and common iliac arteries measured with computed tomography. Radiologist A, B and C.

Table 3. Interobserver differences and variability with computed tomography measurements of abdominal aortic and common iliac artery diameter. The Tromsø Study 1994–95.

	Number of pairs	Mean (95% CI) mm	*p*-value	Variability (mm) *
All measurements	4136	0.48 (0.41, 0.55)		4.5
Reader pair			<0.001	
AB	1372	1.03 (0.91, 1.14)		4.3
AC	1394	0.73 (0.63, 0.83)		3.8
BC	1370	−0.32 (−0.45, −0.19)		4.8
Readings			<0.001	
First reading	2068	0.33 (0.24, 0.43)		4.4
Second reading	2068	0.63 (0.53, 0.73)		4.5
Measurement plane			0.85	
Anterior-posterior	2068	0.49 (0.40, 0.58)		4.1
Transverse	2068	0.47 (0.37, 0.58)		4.8
Measurement level			<0.001	
Aortic level				
Suprarenal	700	0.62 (0.48, 0.75)		3.6
Renal	704	0.43 (0.29, 0.58)		3.9
Bifurcation	684	0.57 (0.31, 0.82)		6.6
Maximal infrarenal	688	0.68 (0.52, 0.84)		4.2
Iliac level				
Right iliac artery	680	0.58 (0.42, 0.73)		4.1
Left iliac artery	680	0.01 (−0.13, 0.14)		3.5
Measurement at			<0.001	
All aortic levels	2776	0.57 (0.48, 0.66)		4.7
Both iliac artery levels	1360	0.29 (0.19, 0.39)		3.9
Ultrasound assessed aneurysm			0.25	
No	2104	0.44 (0.38, 0.51)		3.0
Yes	2032	0.52 (0.40, 0.65)		5.6

* Variability calculated as 1.96 SD of the mean difference.[14]

possible to acquire thinner axial slices of aorta and common iliac arteries, and CT angiography reconstructions provides better visualisation of accessory renal arteries and the neck of the aneurysm. However, both intraobserver and interobserver measurement variability will be present as long as the CT examinations have to be judged by radiologists. To our knowledge, there are no studies of aortic measurement variability with new CT technology. There is a need for similar studies using more modern CT techniques.

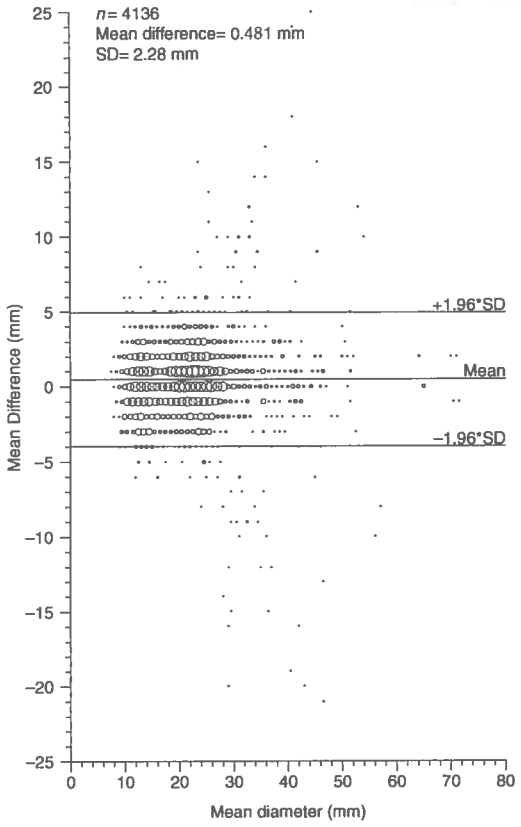

Fig. 4. Plot of interobserver differences against the average diameter of aorta and common iliac arteries measured with computed tomography.

The present study is comprehensive as we examined variability in several levels of the aorta and the common iliac artery, and in both the transverse and anterior-posterior planes. Our study design also made it possible to examine how variability varies between radiologists and with the diameter of the vessel. We selected subjects randomly from a subset of the population-based study for the reproducibility study, and did not alter the CT measurement technique routinely used in our department. Thus, the measurement variability in this study reflects the routine practice in a small university hospital.

There are many reasons for the variability observed. The three different radiologists may have chosen different slices as the slice representing the different levels and the maximal diameter. They may also differ in their interpretation as to what was the outer boundary of the aorta. The relatively large slice thickness (as common in conventional CT), the correction for tortuosity which is more prominent in aneurysmal arteries and the experience of the radiologist may all have contributed to the variability. However, some people are just more accurate than others. In subjects without aneurysms, no intravenous contrast medium was used. There is no reason to believe that this has influenced the variability to any significant extent. Particularly in aortas with an aneurysm, thrombus is relatively frequent. As we have measured the external diameter, this has most likely not influenced the variability.

The interobserver variability was higher for measurements at the bifurcation level than at the maximal infrarenal, suprarenal and common iliac artery level of measurement. This may reflect the ease of assessing the suprarenal level and uncertainty in deciding where the aortic bifurcation began. We found higher variability for measurements in the transverse than in the anterior-posterior plane. This probably reflects problems associated with identifying the outer wall boundary of the vessel in the transverse plane. Similarly, a higher variability was found when measuring aortas with than without a present aneurysm. This would not have been evident if only subjects with aneurysms had been examined and underlines the need for examining the variability not only in the pathological state.

Previous studies have concentrated on the maximal infrarenal diameter.[1,9] In the present study, we found that approximately 95% of the CT measurements of the maximal infrarenal diameter of the abdominal aorta can be performed with accuracy within the limit of 4 mm. The variation was higher for the interobserver than the intraobserver measurements, and higher for measurements in the transverse than in the anterior-posterior plane. In the multi-centre ADAM Study including 806 CT measurement-pairs, the interobserver differences for the maximal infrarenal aortic diameter (in any plane) were 2 mm or less in 65% of the pairs, but 17% differed by 5 mm or more.[9] Our figures were 82 and 6%, respectively. The intraobserver differences in our study are comparable to those found in the ADAM Study.[9] In a hospital-based Finnish study of 33 subjects including both normal and aneurysmatic aortas,[1] the corresponding interobserver differences for maximum aortic diameter were 62 and 12% in the anterior-posterior plane, and 66 and 12% in the transverse plane, respectively. In our study, the comparable figures were 84.9% (2 mm or less) and 2.9% (5 mm or more) for CT measurement of the maximum aortic diameter in the anterior-posterior plane and 83.1 and 5.5%, respectively,

Table 4. Percentages of absolute intra- and interobserver differences in computed tomography measurements of the maximal infrarenal aortic diameter lying within specified limits. The Tromsø Study 1994–95.

Difference	CT Measurement plane			
	Anterior-posterior		Transverse	
	Percent	Cumulative % (95% CI)	Percent	Cumulative % (95% CI)
Intraobserver differences (n = 174 pairs)				
0–1 mm	86.8	86.8 (81.1, 9.12)	78.7	78.7 (72.2, 84.3)
2 mm	9.2	96.0 (92.2, 98.2)	12.1	90.8 (85.8, 94.5)
3 mm	3.4	99.4 (97.2, 100)	4.6	95.4 (91.5, 97.8)
4 mm	0.0	99.4 (97.2, 100)	1.7	97.1 (93.7, 98.9)
5 mm or more	0.6	100	2.9	100
Interobserver differences (n = 344 pairs)				
0–1 mm	63.7	63.7 (58.5, 68.6)	62.8	62.8 (57.6, 67.8)
2 mm	21.2	84.9 (80.8, 88.4)	20.3	83.1 (78.9, 86.8)
3 mm	8.1	93.0 (90.0, 95.4)	7.9	91.0 (87.6, 93.7)
4 mm	4.1	97.1 (94.9, 98.5)	3.5	94.5 (91.7, 96.5)
5 mm or more	2.9	100	5.5	100

in the transverse plane. The study designs differed, however. In the ADAM Study, measurements were done on a hard copy with magnifying glass whereas both in the Finnish study and our study, the radiologists worked on the screen at a workstation using electronic callipers. It is easier to measure on a screen with electronic callipers as also shown by Aarts *et al.*[10]

The intraobserver variability in measurements of the maximum aortic diameter in both plane was less than the interobserver variability, confirming the results for all measurements levels combined (Tables 2 and 4). Similarly, we found that the measurement variability increased somewhat with increasing vessel diameter (Figs 2 and 4). The results for aneurysmatic and normal aortas separately confirm this. The more detailed analysis indicates that this seems to be a major problem only for interobserver variability and for large diameters in the transverse plane, which is in accordance with the results from the Finnish study.[1]

There are at least three clinical implications of our findings. Although not formally tested, our results suggest that experience makes a difference. Radiologist A and B are vascular radiologists and C is a neuroradiologist with limited experience from routine vascular measurements with CT. Therefore, CT measurements should be confined to few hands. Furthermore, when assessing possible growth of an aneurysm, the radiologists should review previous CT-scans and not base the decision on the results from previous measurements conducted by another physician. This will reduce the misclassification due to interobserver variability. Our results suggest that when a radiologist measures the maximal infrarenal aortic diameter, an experienced colleague will probably (in more than 90% of the cases) not differ more than 3 mm. This may in many clinical situations be an acceptable difference.

In conclusion, interobserver variability with CT measurements of aortic and common iliac artery diameter is not negligible and is higher than intraobserver variability. Previous CT-scans should be reviewed simultaneously to exclude the interobserver variability. The data indicate that the variability is influenced by the degree of experience of the radiologist. These results must be born in mind when making clinical decisions.

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References

1 Jaakkola P, Hippelinen M, Farin P, rytkÖnen S, Kainulainen S, Partanen K. Interobserver variability in measuring the dimensions of the abdominal aorta: comparison of ultrasound and computed tomography. *Eur J Vasc Endovasc Surg* 1996; 12: 230–237.

2 Yucel EK, Fillmore DJ, Knox TA, Waltman AC. Sonographic measurement of abdominal aortic diameter: interobserver variability. *J Ultrasound Med* 1991; 10: 681–683.

3 Grimshaw GM, Docker MF. Accurate screening for abdominal aortic aneurysm. *Clin Phys Physiol Meas* 1992; 13: 135–138.

4 Akkersdijk GJ, Puylaert JB, Coerkamp EG, de Vries AC. Accuracy of ultrasonographic measurement of infrarenal abdominal aortic aneurysm. *Br J Surg* 1994; 81: 376.

5 Ellis M, Powell JT, Greenhalgh RM. Limitations of ultrasonography in surveillance of small abdominal aortic aneurysms. *Br J Surg* 1991; 78: 614–616.

6 Thomas PR, Shaw JC, Ashton HA, Kay DN, Scott RA. Accuracy of ultrasound in a screening programme for abdominal aortic aneurysms. *J Med Screening* 1994; **1**: 3–6.
7 Pleumeekers HJ, Hoes AW, Mulder PG, van der Does E, Hofman A, Lameris JS *et al*. Differences in observer variability of ultrasound measurements of the proximal and distal abdominal aorta. *J Med Screen* 1998; **5**: 104–108.
8 Singh K, Bønaa KH, Solberg S, Sørlie DG, Bjørk L. Intra- and interobserver variability in ultrasound measurements of abdominal aortic diameter. The Tromsø study. *Eur J Vasc Endovasc Surg* 1998; **15**: 497–504.
9 Lederle FA, Wilson SE, Johnson GR *et al*. Variability in measurement of abdominal aortic aneurysms. *J Vasc Surg* 1995; **21**: 945–952.
10 Aarts NJM, Schurink GWH, Kool LJS *et al*. Abdominal aortic aneurysm measurement for endovascular repair: intra- and interobserver variability of CT measurements. *Eur J Vasc Endovasc Surg* 1999; **18**: 475–480.
11 Jacobsen BK, Thelle DS. The Tromsø Heart Study: responders and non-responders to a health questionnaire, do they differ? *Scand J Soc Med* 1988; **16**: 101–104.
12 Bønaa KH, Arnesen E. Association between heart rate and atherogenic blood lipid fractions in a population. The Tromso Study. *Circulation* 1992; **86**: 394–405.
13 Singh K, Bønaa KH, Jacobsen BK, Bjørk L, Solberg S. Prevalence of and risk factors for abdominal aortic aneurysms in a population-based study: the Tromsø Study. *Am J Epidemiol* 2001; **154**: 236–244.
14 Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* 1986; **1**: 307–310.
15 Bland JM, Altman DG. Comparing methods of measurement: why plotting difference against standard method is misleading. *Lancet* 1995; **346**: 1085–1087.
16 SAS Institute Inc. SAS/STAT™ User's Guide. Version 6., Cary, NC: SAS Institute Inc., 1989.

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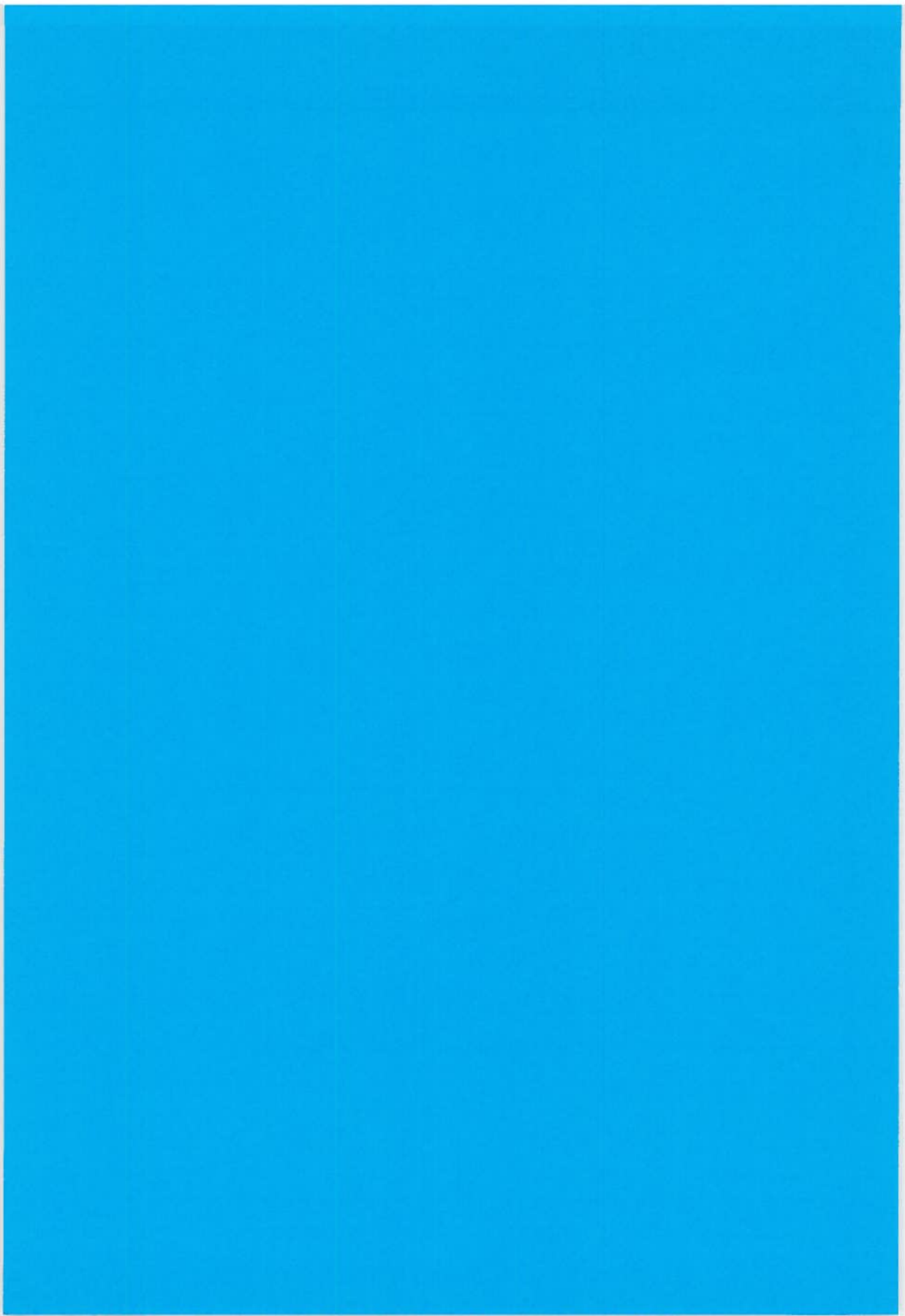
PAPER III



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The Difference Between Ultrasound and Computed Tomography (CT) Measurements of Aortic Diameter Increases with Aortic Diameter: Analysis of Axial Images of Abdominal Aortic and Common Iliac Artery Diameter in Normal and Aneurysmal Aortas. The Tromsø Study, 1994–1995

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Objective. *To assess agreement between ultrasound and computed tomography (CT) measurements from axial images of normal and aneurysmatic aortic and common iliac artery diameter.*
Design. *Part of a population health screening for abdominal aortic aneurysm conducted in 1994–1995.*
Materials and methods. *Three hundred and thirty-four subjects with and 221 subjects without ultrasound-detected aneurysm were scanned with CT. Three technicians and one radiologist measured ultrasonographic diameters and five radiologists measured CT diameters. The paired ultrasound-CT measurement differences were analyzed to assess agreement.*
Results. *Compared to CT measurements, ultrasound slightly underestimated the diameter in normal aortas and tended to overestimate the diameter in aneurysmal aortas. In 555 ultrasound-CT pairs of measurements, the absolute differences for measurements of maximal aortic diameter were 2 mm or less in 62, 60 and 77% in anterior–posterior, transverse and maximum diameter in any plane, respectively. The corresponding figures for an absolute difference of 5 mm or more were 14, 18 and 8%, respectively. Variability increased with increasing diameter.*
Conclusions. *Both ultrasound and CT measurements of abdominal aortic diameter are liable to variability and neither of these methods can be considered to be 'gold standard'. Both methods can be used, while taking variability into consideration when making clinical decisions.*

Key Words: Abdominal aortic aneurysm; Ultrasound; Computed tomography (CT); Variability; Aortic diameter.

Introduction

Ultrasound is cost-effective, easily available and transportable, and has found increasing use in many screening programmes for abdominal aortic aneurysms.[1–3] Due to its extensive use both in screening programmes and in routine abdominal diagnosis, an increasing number of abdominal aortic aneurysms are diagnosed. However, clinical decision making, whether to operate or not, is mostly based on the maximum aortic diameter measured on the computed tomography (CT) scans. Aneurysms, too small to be subject for surgery, are followed with yearly ultrasound examinations. Thus, there is a need for studies concerning how well ultrasound and CT measurements compare. Few studies have addressed the agreement between ultrasound and CT measurements of aortic diameter,[4–9] particularly including aortas both with and without aneurysms.[6,7] Only two studies included more than 100 subjects.[4,5] In a study including aortas with diameter 40–54 mm, Lederle *et al.*[4] found that differences in aortic diameter measured by ultrasound and CT of 5 mm or more were common (33% of the comparisons). In a recently published multi-centre study by Sprouse *et al.*[5] with 334 subjects having endoluminally-repaired aneurysms, the maximal aortic diameter consistently was assessed to be significantly larger by CT than by ultrasound. We previously have published results of intraobserver and interobserver variability in measuring the abdominal aorta by ultrasound[10] and CT.[11] In the present study, we compare the measurements of the abdominal aorta and common iliac arteries by ultrasound and CT in 555 subjects who had undergone

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ultrasound examination of the abdominal aorta as a part of a population based screening survey.

Material and Methods

Study design and measurements

The Tromsø study is a population-based prospective study of inhabitants in the municipality of Tromsø, Norway. The study, with cardiovascular disease as a main focus, has a design which includes repeated population health surveys.[12]

The fourth cross-sectional survey was conducted in 1994–1995. As a part of this study, 6892 subjects attended for ultrasound screening of abdominal aortic aneurysms (79% of the eligible population) as detailed elsewhere.[12] The Regional Committee for Medical Research Ethics approved both the ultrasound[10] and CT[11] study.

Ultrasound study

Measurements of the external aortic and common iliac artery diameter were taken in both anterior–posterior and transverse plane, at different levels as shown in Fig. 1. The abdominal aorta was first visualized in the longitudinal plane tilting the transducer to accommodate for the angulation and tortuosity. The measurements were taken on the screen from true orthogonal axial images frozen in systole. Likewise, both common iliac arteries were examined in the longitudinal plane and measurements taken on axial images, at their origin. Three technicians and one radiologist performed 96% of the ultrasound examinations with 3.5 MHz sector probe and 5 MHz linear probe (Acuson 128-XP). The measurement variability, studied in 112 men and women, was within 4 mm, as published previously.[10] An aortic aneurysm was defined as present if one or more of the following criteria were met: (1) the aortic diameter at the renal level was equal to or greater than 35 mm in either anterior–posterior or transverse plane, (2) the infrarenal aortic diameter was ≥5 mm larger than renal aortic diameter in either plane, (3) a localized dilatation of the aorta was present.

Altogether 348 subjects met these criteria and were referred to the Department of Radiology for routine CT examination, and 334 subjects (96%) attended the CT examination. The subjects with non-aneurysmal aortas were selected from the general population. When contacted by telephone, a short time after the ultrasound screening had taken place, 260 subjects of both sexes with normal aortas indicated willingness to be included in the CT study. After invitation, 203 (78%) subjects agreed to participate. In the present study, we also included 27 subjects with normal aortas, selected from the screening programme, and referred to CT because of incidental findings of abdominal lump or other pathology. Thus, a total of 230 men and women without an aneurysm, as assessed with ultrasound, were included in our study.

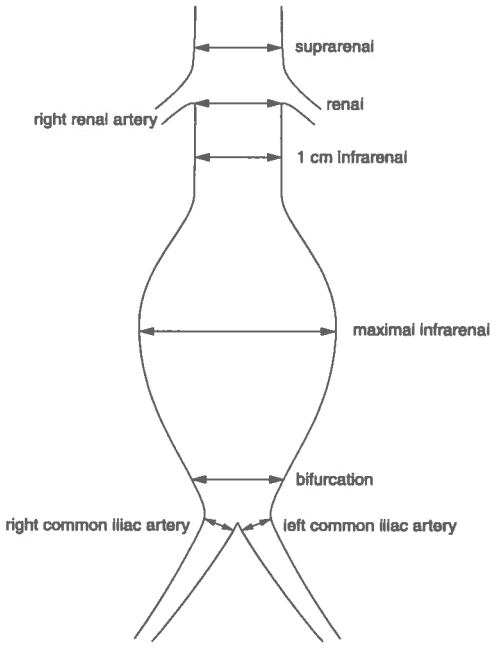

Fig. 1. Different measurement levels of aortic and common iliac artery diameter measurements with ultrasound and computed tomography on axial scans.

The computed tomography (CT) examination

The CT examination was carried out with Siemens CT (Somatom HIQ Type 600 Serial Nr. 8349). The examination was done with 10 mm slice thickness and 10 mm increment. The external aortic and common iliac artery diameters were measured in the anterior–posterior and transverse plane at different levels as shown in Fig. 1.

The CT examination methodology has been described previously.[11] Usually subjects with ultrasound-assessed aneurysms had continuous intravenous contrast injection and subjects without suspected aneurysm had studies without contrast media. There

were 16 exceptions to this rule: CT examination with contrast was performed in eight subjects, with a normal aorta, referred only because of an ultrasound assessed intra-abdominal lump and in a further eight subjects, with aneurysm, the CT examination was done without contrast medium due to known or suspected allergy to the contrast medium or known renal failure. All CT examinations were stored on an optic disc and measurements were made on screen at a workstation, using electronic calipers. The external aortic and common iliac artery diameter was measured both in the anterior–posterior and transverse plane. Efforts were made to obtain true orthogonal anterior–posterior and transverse plane diameter measurements on oblique images resulting from the tortuosity and angulation of aorta and iliac arteries. The participating radiologists had no access to data from the ultrasound examination.

Out of the 564 study subjects, two had cancer and were further referred to the surgery department for evaluation, without aortic measurements after the CT examination. Further, the maximal aortic diameter was impossible to measure by ultrasonography in seven other subjects. Therefore, 555 subjects (334 with and 221 without aneurysm) with ultrasound and CT measured maximal aortic diameter in both anterior–posterior and transverse plane were included in the analysis (Table 1). The measurements taken 1 cm below the renal arteries were not included in our analyses due to the high correlation with the maximal infrarenal diameter in subjects without an aneurysm ($r = 0.98$). The available numbers of ultrasound and CT pairs for measurements at renal, 1 cm infrarenal and bifurcation level were lower due to the difficulty in ultrasound measurement at these levels. The measurements with ultrasound at the suprarenal and both common iliac artery levels were mainly performed by one of the participating radiologists and hence, fewer measurement pairs were available for analysis (Table 2).

Statistical analysis

The differences between ultrasound and CT measurements were estimated by calculating arithmetic difference between repeated measurements on the same subject. Mean differences between ultrasound and CT measurements show the estimated bias. The standard deviation of the differences measures random fluctuations around the mean. Variability was calculated as 1.96 times the standard deviation of the mean arithmetic difference according to Bland and Altman.[13] Limits of agreement were calculated as mean difference ± 1.96 SD. The differences were reasonably normally distributed except for a few outliers. To examine whether measurement variability was of the same magnitude when measuring small or large aortic diameters, we plotted the arithmetic differences between ultrasound and CT measurements against their average diameter. We also estimated variability by calculating the mean absolute difference between ultrasound and CT measurements, and the percentage of the absolute differences 2 mm or less, 3 mm or less, 4 mm or less and 5 mm or less as adopted by Lederle *et al.*[4] The results are also reported as 'clinically acceptable differences' (CAD) as proposed by Jaakkola *et al.*[6] expressing the proportion of differences less than 5 mm.

The associations between the differences and selected factors that may influence use of ultrasound (age, gender, smoking and obesity) were tested by analysis of variance. Two-sided *p*-values less than 0.05 were considered to indicate statistical significance. The SAS software package was used.[14]

Results

Characteristics of the two groups, with and without aneurysm, participating in the present study ($n = 555$) are shown in Table 1. Compared to subjects without an

Table 1. Characteristics of the participants in the computed tomography and ultrasound study

Characteristic	Ultrasound assessed abdominal aortic aneurysm		
	Yes $n = 334$	No $n = 221$	*P* value
Age (years)	66.1 (6.3)	63.3 (9.1)	<0.0001
Male (%)	79.6	54.3	<0.0001
Systolic blood pressure (mmHg)	139.6 (22.0)	136.3 (22.2)	0.10
Serum total cholesterol (mmol/l)	6.57 (1.28)	6.17 (1.30)	0.0005
Plasma fibrinogen (mmol/l)	3.55 (0.87)	3.24 (0.87)	<0.0001
Serum HDL-cholesterol (mmol/l)	1.26 (0.39)	1.35 (0.43)	0.02
Smoking (%)	52.9	28.8	<0.0001
Body mass index (kg/m^2)	26.4 (3.9)	25.5 (3.8)	0.018

Values are age and sex adjusted means (SD), or percent for the two groups with and without aneurysm.

Table 2. Ultrasound and CT measured abdominal aortic and common iliac artery diameter (mm) and paired differences in participating subjects according to ultrasound-assessed aneurysm. The Tromsø study

	Subjects with aneurysm ($n = 334$)				Subjects without aneurysm ($n = 221$)			
	No. of pairs	Ultrasound (mm)	CT (mm)	Difference (SD) (mm)	No. of pairs	Ultrasound (mm)	CT (mm)	Difference (SD) (mm)
Aortic diameter at:								
One cm suprarenal level:	61				25			
Anterior–posterior plane		26.4 (4.3)	25.8 (2.3)	0.6 (4.2)		23.2 (2.5)	23.7 (2.7)	−0.5 (2.2)
Transverse plane		28.9 (6.2)	25.7 (3.0)	3.2 (6.3)		24.0 (2.8)	24.0 (2.6)	0.0 (2.1)
Renal artery level:	303				208			
Anterior–posterior plane		24.0 (4.4)	24.7 (3.4)	−0.7 (3.9)		21.0 (2.9)	22.3 (2.6)	−1.3 (2.4)
Transverse plane		25.3 (5.2)	24.8 (4.2)	0.5 (4.9)		22.1 (3.0)	22.6 (2.8)	−0.5 (2.5)
One cm infrarenal level:	280				206			
Anterior–posterior plane		23.8 (4.6)	24.6 (3.8)	−0.8 (4.1)		19.9 (2.7)	21.6 (2.7)	−1.7 (2.0)
Transverse plane		25.0 (5.5)	24.0 (4.6)	1.0 (5.3)		20.9 (2.9)	21.3 (2.7)	−0.4 (2.2)
Bifurcation level:	315				215			
Anterior–posterior plane		24.4 (6.6)	24.8 (6.1)	−0.4 (5.9)		18.2 (2.8)	19.1 (2.4)	−0.9 (1.8)
Transverse plane		25.9 (7.4)	25.9 (7.2)	0.0 (7.0)		19.1 (2.9)	19.5 (2.5)	−0.4 (2.0)
Maximal infrarenal level:	334				221			
Anterior–posterior plane		34.3 (10.3)	34.6 (10.8)	−0.3 (3.5)		20.1 (2.8)	22.0 (3.0)	−1.9 (2.2)
Transverse plane		36.3 (10.8)	34.6 (11.2)	1.7 (4.5)		21.2 (3.0)	21.9 (3.2)	−0.7 (2.5)
Right common iliac artery	51				25			
Anterior–posterior plane		15.9 (5.3)	16.3 (6.4)	−0.4 (3.3)		13.4 (2.7)	14.2 (2.7)	−0.8 (1.4)
Transverse plane		16.8 (5.4)	16.6 (6.4)	0.2 (4.3)		13.6 (3.0)	14.4 (2.6)	−0.8 (1.7)
Left common iliac artery:	58				26			
Anterior–posterior plane		15.1 (3.1)	15.4 (3.5)	−0.3 (3.2)		12.6 (1.9)	13.4 (1.4)	−0.8 (1.9)
Transverse plane		15.8 (3.8)	14.7 (3.6)	1.1 (3.8)		13.0 (2.1)	13.5 (1.7)	−0.5 (2.4)

Values are mean (SD) mm.

aneurysm, subjects with aneurysm were 2.8 years older, a higher proportion were male and smokers, and they had higher age- and sex-adjusted total serum cholesterol, plasma fibrinogen, body mass index and lower serum HDL cholesterol. Systolic blood pressure was not significantly different in the two groups.

The mean aortic diameter assessed by ultrasound and CT according to measurement plane, aortic level and presence of aneurysm is detailed in Table 2. The mean maximal aortic diameter measured by CT in the anterior–posterior plane was 22.0 and 34.6 mm in normal and aneurysmal aortas, respectively. These measurements were slightly higher than the corresponding ultrasound measurements.

Mean differences

Pooled analysis, including all aortic and both common iliac artery levels, totaled 3686 measurement pairs. The mean difference (95% CI) for ultrasound—CT pairs was −0.20 mm (95% CI: −0.34, −0.07), indicating that diameter was measured slightly lower with ultrasound than CT (Fig. 2 and Table 3). For aortas, with maximal aortic diameter <30 mm, ultrasound underestimated the diameters as compared to CT (mean difference −0.48 mm (95% CI: −0.60, −0.35)). In contrast, ultrasound showed a tendency to give higher readings than CT when the diameter was measured in small (30–39 mm) aortic aneurysms (mean difference 0.22 mm (95% CI: −0.06, 0.50)) and large aortic aneurysms over 39 mm (mean difference 0.31 mm (95% CI: −0.45, 1.07)). Thus, overall, there was a linear trend between the mean difference and maximum aortic diameter measured by ultrasound. This trend was observed for both measurement planes and most measurement levels, including the maximal infrarenal level. In particular, this was reflected in the measurements of the maximum aortic diameter where the mean overall difference was −0.11 mm (95% CI: −0.33, 0.11) for all measurement pairs ($n = 1110$), negative (−0.64 mm) for measurements of normal aortic diameters and positive for measurements of aortic diameters of small (0.67 mm) and large (1.09 mm) aneurysms, confirming the systematic bias in measurements (Table 3).

In the anterior–posterior plane, ultrasound readings were on average lower than CT readings. In the transverse plane measurements, the opposite was true. However, for both planes, the tendency for higher readings from ultrasound than from CT with increasing aortic diameter was observed. Fig. 2 shows the differences between ultrasound and CT measurements according to their average aortic diameter.

When restricting analyses to the readings for the single radiologist participating in both ultrasound and CT examinations ($n = 596$ pairs), the mean difference was −0.50 mm (95% CI: −0.78, −0.22). The mean

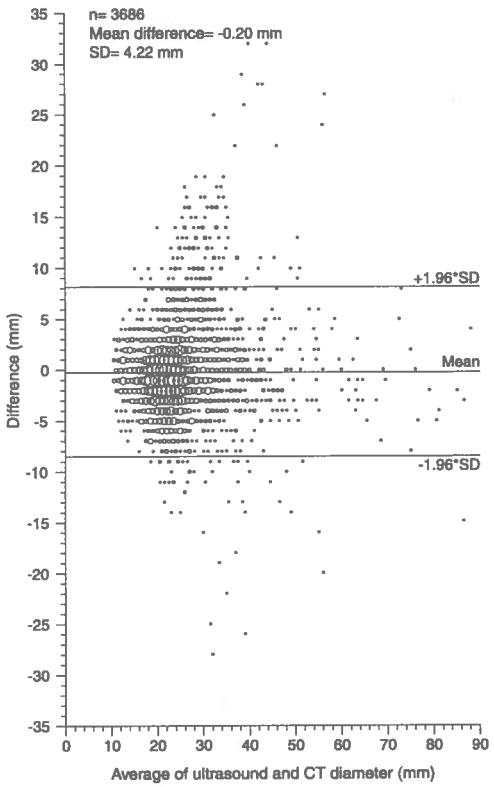

Fig. 2. Plot of ultrasound and computed tomography (CT) measured differences against their average diameter. All measurements at suprarenal, renal, bifurcation and maximal infrarenal aortic and both common iliac artery levels, in both anterior–posterior and transverse plane, are included.

difference was negative for measurements of aortas with maximum aortic diameter <30 mm, −0.51 mm (95% CI: −0.72, −0.30), and small aortic aneurysms, −1.24 mm (95% CI: −1.90, −0.58), but not significantly different from zero for large aortic aneurysms; mean difference 0.93 mm (95% CI: −0.76, 2.62). Therefore, excluding interobserver variation altered the pattern of ultrasound–CT differences.

There were significant correlations between the paired difference and body mass index for measurements of maximum aortic diameter both in the anterior–posterior plane ($r = 0.12$, $p = 0.003$) and transverse plane ($r = 0.23$, $p < 0.001$). However, in the anterior–posterior plane, there was no significant correlation with body mass index in normal aortas. We found no association between the ultrasound–CT differences and current cigarette smoking or gender. For subjects without an aneurysm, the largest mean

Table 3. Differences between ultrasound and CT measurements and variability of abdominal aortic and common iliac artery diameter measurements. The Tromsø study

	Total			Maximal aortic diameter <30 mm*			Maximal aortic diameter 30–39 mm*			Maximal aortic diameter >39 mm*		
	n	Mean (95% CI) mm	Variability	*n*	Mean (95% CI) mm	Variability	*n*	Mean (95% CI) mm	Variability	*n*	Mean (95% CI) mm	Variability†
All measurements	3686	−0.20 (−0.34, −0.07)	8.3	2298	−0.48 (−0.60, −0.35)	6.1	993	0.22 (−0.06, 0.50)	8.7	395	0.31 (− 0.45, 1.07)	15.1
Measurement Plane:												
Anterior–posterior	1842	−0.75 (−0.92, −0.58)	7.3	1149	−1.02 (−1.17, −0.86)	5.3	496	−0.43 (−0.78, −0.08)	7.7	197	−0.03 (−1.00, 0.95)	13.6
Transverse	1844	0.34 (0.13, 0.55)	9.0	1149	0.06 (−0.14, 0.26)	6.7	497	0.87 (0.44, 1.29)	9.4	198	0.64 (−0.54, 1.82)	16.5
Measurement level:												
Suprarenal	172	1.27 (0.54, 1.99)	9.5	86	1.53 (0.46, 2.61)	9.9	64	1.09 (−0.13, 2.31)	9.6	22	0.73 (−1.12, 2.57)	8.2
Renal	1023	−0.40 (−0.63, −0.16)	7.5	662	−0.67 (−0.91, −0.43)	6.1	262	−0.15 (−0.66, 0.35)	8.2	99	0.79 (−0.43, 2.01)	12.0
Bifurcation	1060	−0.39 (−0.70, −0.08)	10.1	682	−0.50 (−0.72, −0.29)	5.6	268	−0.18 (−0.84, 0.48)	10.8	110	−0.19 (−2.36, 1.98)	22.5
Maximal infrarenal	1110	−0.11 (−0.33, 0.11)	7.2	700	−0.64 (−0.87, −0.42)	6.0	282	0.67 (0.23, 1.12)	7.5	128	1.09 (0.11, 2.07)	11.0
Right common iliac a	153	−0.31 (−0.84, 0.21)	6.4	80	−0.09 (−0.68, 0.50)	5.2	55	0.24 (−0.67, 1.14)	6.6	18	−3.00 (−5.14, −0.86)	8.5
Left common iliac a	168	0.09 (−0.40, 0.58)	6.3	88	0.19 (−0.43, 0.82)	5.8	62	0.55 (−0.29, 1.38)	6.4	18	−2.00 (−3.83, −0.17)	7.2

*Grouped after ultrasound measured maximal anterior–posterior aortic diameter.
†Variability is calculated as 1.96*standard deviation of the mean difference.

difference between the ultrasound and CT measurements was associated with increased age (aged 70 and above), whereas in subjects with an aneurysm, the largest mean difference was in younger subjects (<55 years old). The largest difference between ultrasound and CT measurements (3.3 mm) was found in subjects with an aneurysm and aged 55 or less (results not shown in the tables).

The variability and the limits of agreement

The variability, defined as 1.96 SD of the mean differences within which 95% of the measurement differences are expected to lie, was 8.3 mm in the pooled analysis of all aortic and iliac artery levels in the two planes. Limits of agreement were −8.5, 8.1 mm. The variability increased from 6.1 mm (normal aortas) to 8.7 mm (small aneurysms) and to 15.1 mm for measurements of aortic diameters in large aneurysms (Table 3). The same pattern of variability was observed for measurements in the anterior–posterior and transverse plane and at renal, bifurcation and maximal infrarenal aortic levels. For measurements of the maximum infrarenal aortic diameter, the variability increased from 6.0 mm for measurements of normal aortic, to 7.5 mm for small aneurysm, to 11.0 mm for large aneurysm diameters. Variability was highest for measurements at the bifurcation level for aortic diameters of 40 mm or more (Table 3).

A similar, but less prominent pattern of variability was evident from the measurements of both ultrasound and CT by the same radiologist (variability 4.7, 4.4 and 17.8 mm, respectively). One individual, with a congenital anomaly of urinary system ('horseshoe kidney'), had false positive detection of a large aneurysm at ultrasound examination. When this subject was excluded from the analysis, there was no significant difference in variability in measuring the maximum diameter in normal, small and large diameters (variability reduced to 6.6 mm in the group of large diameters). Variability for this radiologist for common iliac artery measurements was lower than at other levels and there was no evidence for an increase in difference and variability with increasing diameter measured (results not shown in the tables). We found no consistent pattern of difference in the variability according to gender, age, current smoking and body mass index (results not shown in the tables).

Absolute differences

For measurements of the maximal aortic diameter in the anterior–posterior plane, the absolute differences (95% CI) between ultrasound and CT measurements were 2 mm or less in 62% (95% CI: 58, 66), 3 mm or less in 78% (95% CI: 75, 82), and 4 mm or less in 87% (95% CI: 83, 89) of the measurement pairs, respectively (Table 4). Only 14 and 18% of the differences were 5 mm or more in the anterior–posterior and transverse plane measurements, respectively (Fig. 3). Hence, the clinically acceptable difference (CAD, the proportion of the differences less than 5 mm) value was 87 and 83% for measurements in the anterior–posterior and transverse plane, respectively. For measurement of maximum infrarenal aortic diameter in any plane, only 8% of the absolute differences were 5 mm or more (CAD value 92%). For non-aneurysmal aortas, the CAD value was 87 and 90% in the two measurement planes, respectively. For aneurysmal aortas, the corresponding CAD values were 86 and 77%, respectively. Only 1 and 6% of the measured differences in aneurysmal aortas were 10 mm or more in the two

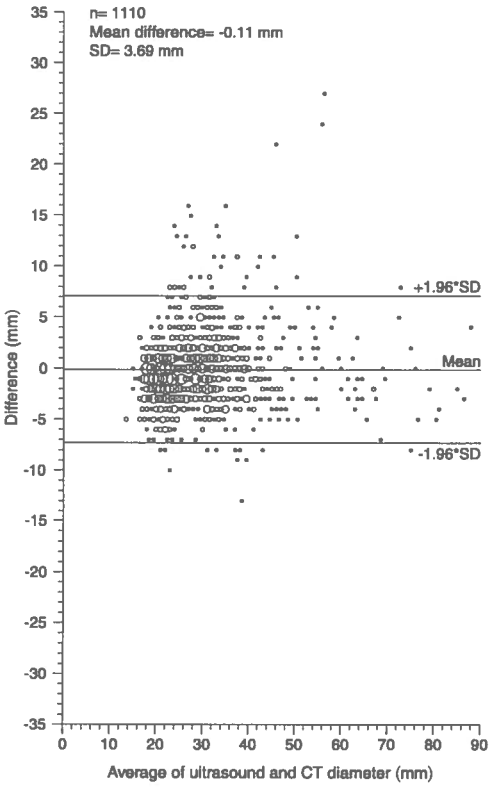

Fig. 3. Plot of ultrasound and CT measured differences against their average diameter for measurements at the maximal infrarenal aortic diameter level in both anterior–posterior and transverse plane.

Table 4. Percentages of absolute differences in computed tomographic and ultrasound measurements of the maximal infrarenal aortic diameter lying within specified limits. The Tromsø study

	Measurement Plane					
	Anterior–posterior		Transverse		Maximal diameter in any plane	
Difference	Percent	Cumulative% (95% CI)	Percent	Cumulative % (95% CI)	Percent	Cumulative % (95% CI)
$n = 555$						
0–1 mm	40.9	40.9 (36.8, 45.1)	40.5	40.5 (36.5, 44.7)	63.8	63.8 (59.7, 67.7)
2 mm	21.1	62.0 (57.9, 66.0)	19.3	59.8 (55.7, 63.8)	13.2	76.9 (73.3, 80.3)
3 mm	16.4	78.4 (74.8, 81.7)	13.7	73.5 (69.7, 77.1)	9.6	86.5 (83.4, 89.1)
4 mm	8.1	86.5 (83.4, 89.1)	9.0	82.5 (79.2, 85.5)	5.6	92.1 (89.6, 94.1)
5 mm or more	13.5	100	17.5	100	7.9	100
Ultrasound and CT measurements by the same radiologist ($n = 57$)						
0–1 mm	47.4	47.4 (34.7, 60.3)	50.9	50.9 (38.0, 63.7)	64.9	64.9 (51.9, 76.4)
2 mm	22.8	70.2 (57.4, 80.9)	17.5	68.4 (55.6, 79.5)	21.1	86.0 (75.1, 93.3)
3 mm	21.1	91.2 (81.6, 96.7)	17.5	86.0 (75.1, 93.3)	8.8	94.7 (86.3, 98.6)
4 mm	5.3	96.5 (88.9, 99.4)	1.8	87.7 (77.2, 94.5)	0.0	94.7 (86.3, 98.6)
5 mm or more	3.5	100	12.3	100	5.3	100

planes, respectively. All the differences were 8 mm or less for the measurement of normal aortas.

For intraobserver ultrasound and CT comparisons using a single radiologist ($n = 57$), the absolute differences of maximum aortic diameter were 5 mm or more in 4 and 12% in the anterior–posterior and transverse plane, respectively. The absolute differences for measurements of maximum aortic diameter in any direction were 3 mm or less in 95% (95% CI: 86, 99) and 5 mm or more in 5% of measurement pairs.

Although outside the main focus of this paper, we noted that 274 (82%) of the 334 subjects with ultrasound-assessed aortic aneurysm had the diagnosis confirmed by CT. Aortic aneurysms affected either single or both common iliac arteries in 13% of the subjects. In nine subjects the aneurysms extended to the left common iliac artery, in 14 to the right common iliac artery and in 19 of the subjects the aortic aneurysm affected both common iliac arteries, as assessed by CT.

Discussion

There are two principal findings of this study. First, ultrasound underestimates aortic diameter in measurements of normal-sized aortas (<30 mm) as compared to CT, whereas the opposite seems to be true for aneurysmal aortas. Second, measurement variability increases with increasing aortic diameter. However, the differences in diameter of the aorta, measured with ultrasound and CT, both in subjects with normal aortas and aneurysms, were relatively small (the mean difference was less than 1 mm for most comparisons) and of little or no clinical importance. Therefore, the clinically important finding is the increasing measurement variability with increasing aortic diameter.

There is no consensus concerning the definition of an aortic aneurysm and most published reports use some cut-off point of the measured maximum aortic diameter. This makes it difficult to compare the results from different studies.[7] However, results from comparable studies of ultrasound and CT measurement of maximal aortic diameter are tabulated in Table 5, together with results from our own study. There are only two previously published studies dealing with normal aortic diameter,[6,7] both studies were small (<29 subjects compared to 221 subjects in our study). The reported standard deviations of the measured differences in these studies (Table 5) were comparable and relatively small.

For aneurysmal aortas, there is less agreement among previous studies regarding paired differences and variability. Only two of these previous studies included more than 100 subjects.[4,5] When we compared our results to the results from the large study by Lederle *et al.* (including 258 subjects), we observed a lower proportion of absolute differences exceeding 2 and 5 mm. The recent study by Sprouse *et al.*[5] showed a much higher level of disagreement between ultrasound and CT measurements, 49% of the paired differences exceeding 10 mm. Thus, the disagreement observed in our study between ultrasound and CT measurements is lower compared to these two other large studies.[4,5]

Our results for measuring the aortic diameter showed the largest variability at the bifurcation level measurements, reflecting the difficulty in deciding what constitutes the bifurcation with both ultrasound and CT. At the level of the iliac artery, the standard deviation of the difference between the diameter measured by ultrasound and CT did not seem to depend on the maximum aortic diameter, and the limits of agreement were narrower than at aortic

Table 5. Studies on comparison between ultrasound and CT measurements of maximal infrarenal aortic diameter in subjects with and without aneurysms

Study	Type of study	*n*	Mean difference ultrasound–CT (mm)	SD (mm)	95% limits of agreement	Absolute differences (%)		
						2 mm or less	5 mm or more	10 mm or more
Studies with and without aneurysms								
Jaakkola[6]	Clinical	33	−2.1	–	–	54	16	–
Thomas[8]	Clinical	36	−4.4	3.2	−10.7, 1.9	–	–	–
Wanhainen[7]	Epidemiological	61	+0.9	4.0	−7.1, 8.9	44	25	0
Present study	Epidemiological	555						
AP plane			−0.97	3.2	−7.2, 5.2	62	14	6
TR plane			0.75	4.0	−7.0, 8.5	60	18	4
Studies with aneurysms								
Jaakkola[6]	Clinical	19	−2.6	3.9	−10.4, 5.2	48	26	–
Ellis[9]	Clinical	10 + 9	+0.1–3.1	–	–	–	–	–
Lamah[15]	Clinical	93	−3.8	na	na	na	na	na
Gomes[16]	Clinical	28	−1.0	–	–	–	–	57
Grimshaw[17]	Epidemiological	20	−0.1	1.8	−3.5, 3.4	–	–	–
Lederle[4]	Epidemiological	258	−2.7	4.9	−12.4, 7.0	44	33	–
Wanhainen[7]	Epidemiological	33	−0.7	4.1	−8.8, 7.5	42	24	0
Sprouse[5]	Clinical	334	−9.4	6.9	−22.9, 4.1			48
Present study	Epidemiological	334						
AP plane			−0.34	3.5	−7.3, 6.6	62	14	1
TR plane			1.7	4.5	−7.0, 10.5	52	23	6
Studies without aneurysms								
Jaakkola[6]	Clinical	14	−1.5	2.1	−6.2, 2.0	61	5	–
Wanhainen[7]	Epidemiological	28	+2.8	2.9	−2.9, 8.5	46	25	0
Present study	Epidemiological	221						
AP plane			−1.9	2.2	−6.2, 2.3	62	13	0
TR plane			−0.7	2.5	−5.5, 4.1	72	10	0

levels. However, this finding might have resulted from the diameter of the iliac arteries being measured by ultrasound, mainly by a radiologist with more experience than the technicians and only measurements at the origin of common iliac arteries were included in the analysis, not measurements of few isolated iliac aneurysms.

The variability between these two methods may involve differences in observer, time of testing, and method of measurement, technology used and the definition of the measurement site. In our study, six different radiologists participated in routine CT measurements although majority of measurements (91%) were done by three of the participating radiologists. Four persons performed the majority of ultrasound measurements (16% by the radiologist, 11, 24 and 45% by the three technicians, respectively). The intraobserver variability was considerably less than interobserver variability for both ultrasound and CT measurements.[10,11] When single observer measurements were analysed, eliminating the interobserver variability, the trend to measure smaller diameters by ultrasound in normal aortas and equal or larger diameters in aneurysmal aortas was reduced. This confirms the desirability of reducing the number of observers in measurements in order to reduce variability. Therefore, efforts should be made to restrict measurements to as few hands as possible in order to reduce or eliminate interobserver variability. Several different observers, for both ultrasound and CT measurements in our study, may have contributed to the increased variability. Other factors, such as pulsatility, also could have contributed to the variability in our study. Although we controlled for pulsatility by freezing the axial images in systole during ultrasound measurements, this was not possible during conventional CT imaging. On the other hand, our results probably reflect the variability in routine clinical work.

We measured the external diameter of aorta at different levels and of both common iliac arteries (Fig. 1) on the axial scans, both in the anterior–posterior and transverse plane. It was left to the individual observers to decide which scans represented the suprarenal, renal, 1 cm infrarenal, bifurcation and maximal infrarenal level of measurement. Selection of different scans for the same level measurements may have contributed to the variability. Difficulties in deciding what constituted the outer boundary of aortic wall, with both ultrasound and CT, may also have contributed to the variability. The difficulty in measuring the true orthogonal anterior–posterior and transverse diameter on oblique axial images with CT because of tortuous and angled arteries is well recognized and probably contributed to the disagreements shown in our study.

Due to the use of contrast medium during the CT examination of subjects with an aneurysm, it was possible to infer that the subject had a screening-detected aneurysm. This may have influenced the measurement of the diameter with CT of borderline aneurysms, which might have increased variability in these specific cases. However, it is unlikely that this could have had any major influence on the overall measurement variability.

Both ultrasound and CT technology are under continuous development. In the developed world, rapid multislice CT has largely replaced the conventional CT technology used in this study. The multislice technology makes it possible to rapidly acquire thinner axial slices of aorta and common iliac arteries with multi-planar angiographic reconstructions and volumetric measurements. Basic information and measurement variability remains as long as physicians evaluate the scans and conventional CT technology is still in use in many centers, with measurements made manually on axial images. With more modern CT technology it is possible to reduce misclassification due to tortuosity of the arteries and gain additional information about accessory renal arteries and the extent of renal artery involvement in juxtarenal aneurysms. It is a major challenge to study measurement reproducibility with the new measurement technologies and to determine the comparability with other techniques that are less costly and without radiation hazards, like ultrasonography.

Our study shows that there is a considerable disagreement between ultrasound and CT measurements of aortic diameter, confirming previous reports largely based on small studies. However, the disagreement observed in our study was lower than two previous large studies.[4,5] Neither ultrasound nor CT represents the 'gold standard'. Ultrasound should be used as a screening tool as it has clear advantage of being cheap, transportable and without radiation hazard. CT has better anatomical and morphological resolution and is a method of choice for preoperative assessment of aneurysms. There is a major challenge in deciding which method should be used for the periodic clinical follow up of patients with small and medium sized aneurysms and endoluminally stent-graft repaired aortic aneurysms.

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References

1 Ashton HA, Buxton MJ, Campbell HE. Multicentre aneurysm screening study (MASS): cost effectiveness analysis of screening for abdominal aortic aneurysms based on four year results from randomised controlled trial. *BMJ* 2002; **325**:1135–1138.
2 Pleumeekers HJCM, Hoes AW, van der Does E *et al.* Aneurysms of the abdominal aorta in older adults. The Rotterdam study. *Am J Epidemiol* 1995; **142**:1291–1299.
3 Lederle FA, Johnson GR, Wilson SE *et al.* Prevalence and associations of abdominal aortic aneurysm detected through screening. *Ann Intern Med* 1997; **126**:441–449.
4 Lederle FA, Wilson SE, Johnson GR *et al.* Variability in measurement of abdominal aortic aneurysms. *J Vasc Surg* 1995; **21**:945–952.
5 Sprouse LR, Meier GH, Le Sar CJ, De Masi RJ, Sood J, Parent FN, Marcinzyck MJ, Gayle RG. Comparison of abdominal aortic aneurysm diameter measurements obtained with ultrasound and computed tomography: is there a difference? *J Vasc Surg* 2003; **38**:466–471.
6 Jaakkola P, Hippeläinen M, Farin P *et al.* Interobserver variability in measuring the dimensions of the abdominal aorta: comparison of ultrasound and computed tomography. *Eur J Vasc Endovasc Surg* 1996; **12**:230–237.
7 Wanhainen A, Bergqvist D, Björck M. Measuring the abdominal aorta with ultrasonography and computed tomography—difference and variability. *Eur J Vasc Endovasc Surg* 2002; **24**: 428–434.
8 Thomas P, Shaw J, Ashton H *et al.* Accuracy of ultrasound in a screening programme for abdominal aortic aneurysms. *J Med Screening* 1994; **1**:3–6.
9 Ellis M, Powell JT, Greenhalgh RM. Limitations of ultrasonography in surveillance of small abdominal aortic aneurysms. *Br J Surg* 1991; **78**:614–616.
10 Singh K, Bønaa KH, Solberg S *et al.* Intra- and interobserver variability in ultrasound measurements of abdominal aortic diameter. The Tromsø study. *Eur J Vasc Endovasc Surg* 1998; **15**: 497–504.
11 Singh K, Jacobsen BK, Solberg S, Bønaa KH, Kumar S, Bajic R, Arnesen E. Intra- and interobserver variability in the measurements of abdominal aortic and common iliac artery diameter with computed tomography. The Tromsø study. *Eur J Vasc Endovasc Surg* 2003; **25**:399–407.
12 Singh K, Bønaa KH, Jacobsen BK *et al.* Prevalence of and risk factors for abdominal aortic aneurysms in a population-based study: the Tromsø study. *Am J Epidemiol* 2001; **154**:236–244.
13 Bland JM, Altman DG. Measuring agreement in method comparison studies. *Stat Methods Med Res* 1999; **8**:135–160.
14 SAS Institute Inc, *SAS/STAT™ User's Guide. Version 8*. Cary, NC: SAS Institute Inc, 2000.
15 Lamah M, Darke S. Value of routine computed tomography in the preoperative assessment of abdominal aortic aneurysm replacement. *World J Surg* 1999; :1076–1081.
16 Gomes MN, Hakkal HG, Schellinger D. Ultrasonography and CT scanning: a comparative study of abdominal aortic aneurysms. *Comput Tomogr* 1978; **2**:99–109.
17 Grimshaw GM, Docker MF. Accurate screening for abdominal aortic aneurysm. *Clin Phys Physiol Meas* 1992; :135–138.

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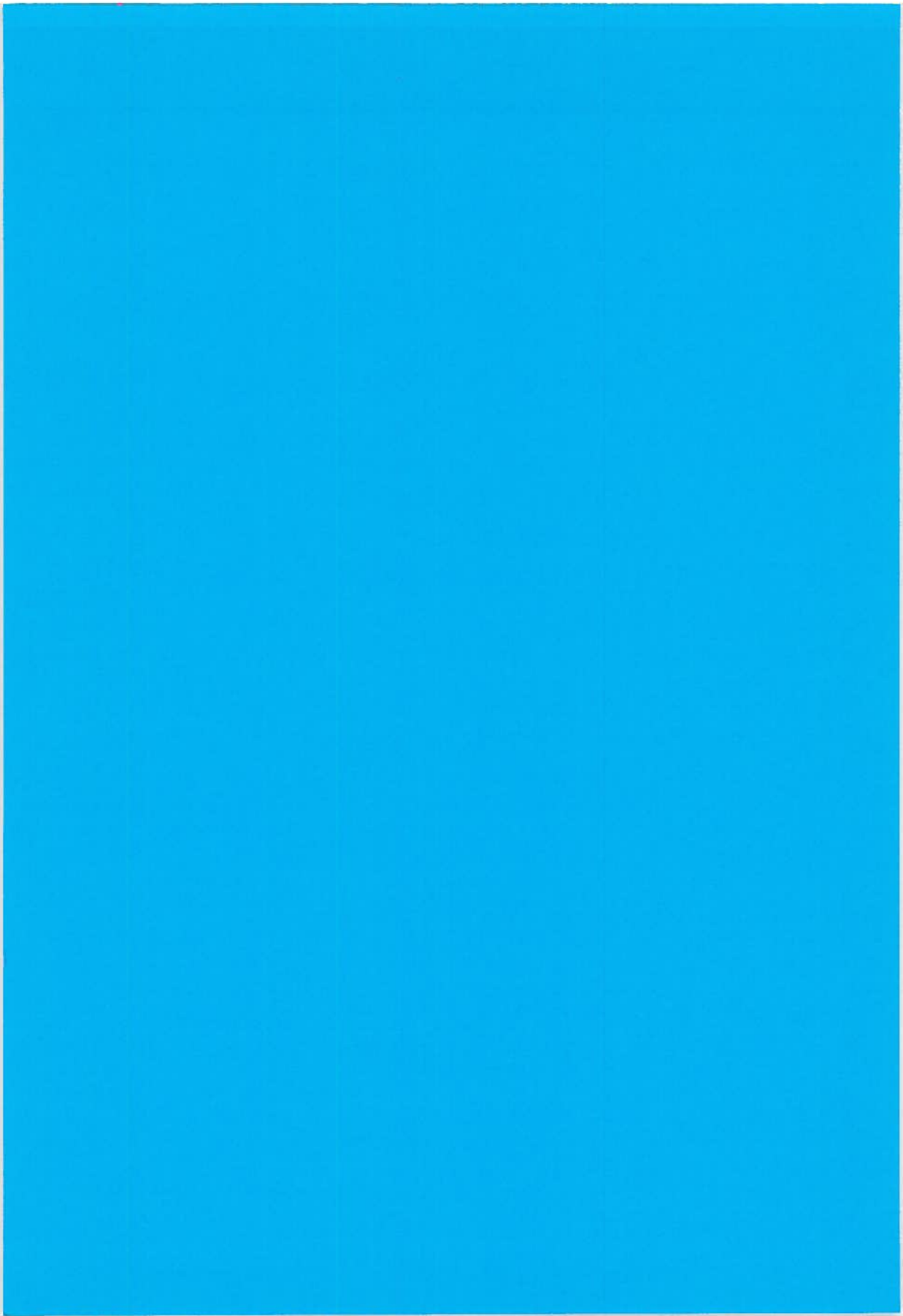
PAPER IV



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Prevalence of and Risk Factors for Abdominal Aortic Aneurysms in a Population-based Study

The Tromsø Study

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In a population-based study of 6,386 men and women aged 25–84 years in Tromsø, Norway, in 1994–1995, the authors assessed the age- and sex-specific distribution of the abdominal aortic diameter and the prevalence of and risk factors for abdominal aortic aneurysm. Renal and infrarenal aortic diameters were measured with ultrasound. The mean infrarenal aortic diameter increased with age. The increase was more pronounced in men than in women. The age-related increase in the median diameter was less than that in the mean diameter. An aneurysm was present in 263 (8.9%) men and 74 (2.2%) women ($p < 0.001$). The prevalence of abdominal aortic aneurysm increased with age. No person aged less than 48 years was found with an abdominal aortic aneurysm. Persons who had smoked for more than 40 years had an odds ratio of 8.0 for abdominal aortic aneurysm (95% confidence interval: 5.0, 12.6) compared with never smokers. Low serum high density lipoprotein cholesterol was associated with an increased risk for abdominal aortic aneurysm. Other factors associated with abdominal aortic aneurysm were a high level of plasma fibrinogen and a low blood platelet count. Antihypertensive medication (ever use) was significantly associated with abdominal aortic aneurysm, but high systolic blood pressure was a risk factor in women only. This study indicates that risk factors for atherosclerosis are also associated with increased risk for abdominal aortic aneurysm. *Am J Epidemiol* 2001; 154:236–44.

aneurysm; aorta, abdominal; lipoproteins, HDL cholesterol; prevalence; risk factors; ultrasonography

An abdominal aortic aneurysm presents none or few symptoms until rupture. The risk of rupture increases with the increasing diameter of the aneurysm. In those suffering a ruptured abdominal aortic aneurysm, the mortality is 60–80 percent (30–65 percent if reaching a hospital alive) (1, 2). With an elective operation, the mortality is 3–7 percent (3–7). Death from a ruptured abdominal aortic aneurysm accounts for about 1 percent of all the deaths in the Western world (8).

Several large studies have addressed the epidemiology of abdominal aortic aneurysms (8–16). Atherosclerosis is probably an important factor in the etiology of abdominal aortic aneurysm, although disturbances in the connective tissue metabolism may also be involved (9, 17–22). A number of studies have shown that abdominal aortic aneurysm and atherosclerosis share many risk factors such as age, smoking, hypercholesterolemia, and hypertension (11, 16, 23–26).

Some previous studies of abdominal aortic aneurysm have been population based (8–10, 12, 13, 27), but the definition of abdominal aortic aneurysm has differed, making comparisons of prevalence rates difficult. It has been known for more than 150 years that abdominal aortic aneurysm is four times more frequent in men than in women (28). Thus, several studies have been performed among men only (8, 11, 12, 14). Studies including both genders are important as there may be differences between the genders with regard to risk factors.

Smoking has been emphasized as an independent risk factor for abdominal aortic aneurysm (9, 16, 23, 29, 30), but only two of the larger population-based studies (9, 30) have addressed smoking in detail. The role of high density lipoprotein (HDL) cholesterol in the development of abdominal aortic aneurysm has been the subject of several studies. In most studies, high HDL cholesterol has been found to correlate with a low prevalence of abdominal aortic aneurysm (9, 18, 19, 25, 31–33), but there have also been negative findings (13). It is presently unknown whether hypertension is a risk factor for abdominal aortic aneurysm. Some studies indicate such a relation (16, 27, 29, 30, 34–36), while other studies found no association (5, 13, 14, 24).

The aim of the present report was to study the prevalence of and risk factors for abdominal aortic aneurysm, as well as

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Abbreviations: CI, confidence interval; HbA_{1c}, glycated hemoglobin; HDL, high density lipoprotein.

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the distribution of infrarenal aortic diameter, in both men and women in a general population.

MATERIALS AND METHODS

Study design

The Tromsø Study was started in 1974 and is a population-based, prospective study of inhabitants in the municipality of Tromsø, Norway. The aims of the study are to investigate the determinants of chronic diseases in order to assess etiologic significance and to investigate potentially modifiable determinants that may be developed into preventive or therapeutic strategies. The main focus is on cardiovascular diseases. The study design includes repeated population surveys to which total birth cohorts and random samples are invited. The regional ethical committee has approved the study.

The fourth cross-sectional survey of the Tromsø population started in September 1994 and was completed in October 1995. The study comprised two screening visits 4–12 weeks apart. All inhabitants 25 years or older were invited to the first visit, and 27,159 subjects, 77 percent of the eligible population, participated. A protocol similar to that used in the previous surveys in this population (37) was followed. The examination included standardized measurements of height, weight, blood pressure, nonfasting serum lipids, and blood cell counts. A self-administered questionnaire handed in at the screening examination covered information about current and previous cigarette smoking, physical activity in leisure time, currently or previously treated hypertension, and a medical history of angina pectoris, diabetes mellitus, asthma, myocardial infarction, and stroke. Persons were classified as having low physical activity in leisure time if they denied any high intensity physical activity and had low intensity activity less than 3 hours per week during the last year before the survey.

All subjects aged 55–74 years and a random 5–10 percent sample in the other age groups were eligible for the second visit. Eligible subjects also included a small group of men aged 40–54 years (see below) previously identified as having a high risk of coronary heart disease (38). All eligible subjects who attended the first screening were, at the first screening, invited to the second visit, which comprised inter alia ultrasonographic measurements of aortic diameters, waist and hip circumference, and blood sampling. A total of 6,892 subjects, 79 percent of those who were eligible, were subject to ultrasound measurements of the abdominal aortic diameter. The age-specific attendance rates (based on age by December 31, 1994) were 62, 81, 83, 79, and 58 percent in the age groups 25–44, 45–54, 55–64, 65–74, and 75–84 years, respectively. Thirty-seven attendees who had previous surgeries to insert a graft in the abdominal aorta, 320 men (aged 40–54 years) who belonged to the nonrandom sample of men with a high risk of cardiovascular disease, and 149 subjects (2.2 percent) whose abdominal aorta was not visualized sufficiently to make exact diameter measurements were excluded from further analysis. Thus, 6,386 (2,962 men and 3,424 women) subjects were included in the analysis.

Cardiovascular risk factors

Height and weight were measured in light clothing without shoes. Body mass index was calculated as the weight divided by the square of height (kg/m^2). The waist/hip ratio was calculated as the waist circumference divided by the maximal hip circumference. Blood pressure was recorded before blood sampling in a separate, quiet room with only a nurse present. An automatic device (Dinamap Vital Signs Monitor 1846; Criticon, Inc., Tampa, Florida) was used. After the participant had been seated for 2 minutes, three recordings were made at 2-minute intervals. The lower of the two last values of blood pressure was used. A venipuncture was performed with the subjects in a sitting position. A short-lasting venous stasis applied to the upper arm was released before blood sampling. Serum total cholesterol and triglycerides were analyzed by enzymatic colorimetric methods with commercial kits (CHOD-PAP for cholesterol and GPO-PAP for triglycerides; Boehringer-Mannheim, Mannheim, Germany). Serum HDL cholesterol was measured after the precipitation of lower density lipoprotein with manganese chloride. Plasma fibrinogen was measured using PT-Fibrinogen reagent (Instrumentation Laboratory, Milan, Italy). Serum creatinine was measured by the HiCo Creatinine Jaffé method with a kinetic colorimetric assay on automated clinical chemistry analyzers (Boehringer-Mannheim). Glycated hemoglobin (HbA_{1c}) was measured from the hemolysate by a latex-enhanced turbidimetric immunoassay (Unimate 3 HBA1C; Roche Diagnostics Corporation, Indianapolis, Indiana). The analyses were done at the Department of Clinical Chemistry, University Hospital of Tromsø, Norway. Hypertension was defined as a systolic blood pressure of >160 mmHg, a diastolic blood pressure of >95 mmHg, or drug treatment for hypertension (current or previous). Pack-years were calculated as the number of cigarettes smoked per day (previously or currently) multiplied by the duration of smoking (years) divided by 20.

Ultrasonography of the abdominal aorta

The ultrasonographic measurements of the abdominal aorta were performed by four examiners as described previously (39). The subjects were examined in the supine position and/or in the left decubitus position when necessary. No instructions on food or fluid intake were given prior to the examination. The examination was carried out with a 3.5-MHz sector probe (Acuson 128-XP; Acuson Corporation, Mountain View, California). The abdominal aorta was first visualized in the longitudinal plane and was examined from the diaphragm to the bifurcation. The aorta was then examined in the axial plane with scans perpendicular to the longitudinal plane. Aortic diameters were measured at the level of the renal arteries, 1 cm distal to this level, and at the bifurcation level. In addition, the maximal infrarenal aortic diameter was measured. Both transverse and anterior-posterior diameters were measured. The external aortic diameter was measured with electronic calipers in both the anterior-posterior and transverse planes. All the measurements were

made online on images that were frozen in systole. The inter- and intraobserver variability was determined at the beginning and at the end of the study. Measurement variability, estimated both as the mean absolute difference between two measurements and as 2 standard deviations of the mean arithmetic difference, was less than 4 mm for measurements of the maximal infrarenal aortic diameter (39).

An abdominal aortic aneurysm was present if one or more of the following criteria were met: 1) the aortic diameter at the renal level was equal to or greater than 35 mm in either the anterior-posterior or the transverse plane; 2) the infrarenal aortic diameter was ≥5 mm larger than the renal aortic diameter in either plane; and/or 3) a localized dilatation of the aorta was present. If an abdominal aortic aneurysm was suspected to be present, the patients were examined by computed tomography and referred to the Department of Cardiovascular Surgery for clinical evaluation and follow-up.

Statistical analysis

Age-adjusted characteristics of men and women with and without an abdominal aortic aneurysm were calculated using analysis of variance. Associations between abdominal aortic aneurysm and cardiovascular risk factors as well as prevalent cardiovascular diseases were determined by using multiple logistic regression. Age was included in the analysis as age at the ultrasound examination. Ninety-five percent confidence intervals were calculated. Two-sided p values were used throughout, and $p < 0.05$ was considered to indicate statistical significance. The SAS software package was used (40).

RESULTS

Figure 1 summarizes descriptive measures of maximal infrarenal aortic diameter in the anterior-posterior plane measured with ultrasound. The mean maximal infrarenal anterior-posterior diameter was 22.5 (standard deviation, 5.4) mm in men and 19.1 (standard deviation, 3.3) mm in women. The difference in diameter between the genders was statistically significant ($p < 0.001$). The mean aortic diameter increased with age in both men and women ($p < 0.001$), although the increase was more pronounced in men. The median, however, did not increase much after the age of 55 years (figure 1). From the age of 55 years, there was a pronounced increase in standard deviation and skewness, particularly in men (data not shown).

An abdominal aortic aneurysm, as defined in our study, was present in 263 (8.9 percent) men and in 74 (2.2 percent) women (table 1; figure 2). The prevalence in men and women differed significantly ($p < 0.001$). Only 46 men (1.6 percent) and eight women (0.2 percent) had abdominal aortic aneurysm solely defined as a visible localized aortic dilatation, and 21 men (0.7 percent) and seven women (0.2 percent) had abdominal aortic aneurysm solely defined as a renal aortic diameter greater than 34 mm. Thus, the majority of the cases of abdominal aortic aneurysm had an infrarenal diameter of ≥5 mm larger than the aortic diameter at the level

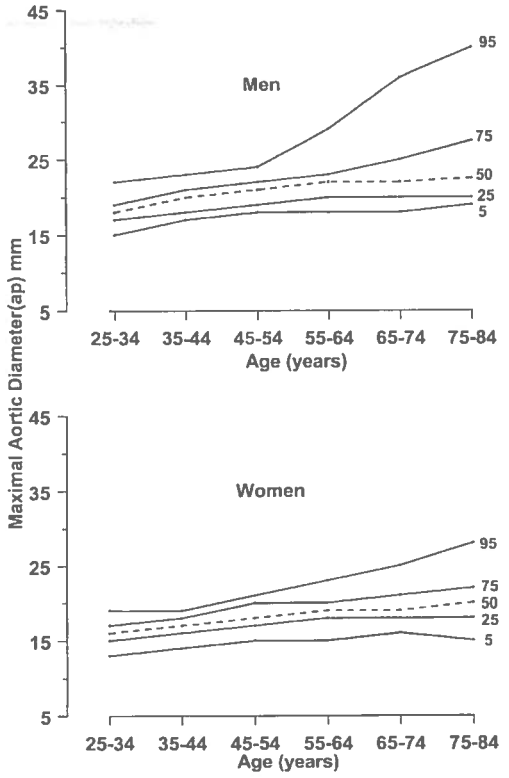

FIGURE 1. Percentile distribution of ultrasound-measured maximal infrarenal aortic diameter (anterior-posterior (ap) plane) by age and gender, The Tromsø Study, 1994–1995. Top, men; bottom, women.

of renal arteries. The prevalence of abdominal aortic aneurysm defined as a maximal infrarenal aortic diameter of >29 mm or >39 mm was 8.2 percent and 1.7 percent in men and 2.3 percent and 0.4 percent in women, respectively (table 1). There was no abdominal aortic aneurysm in subjects under the age of 48 years, and no persons under the age of 55 years had an aortic diameter above 39 mm. The prevalence of abdominal aortic aneurysm increased with age in both men and women ($p < 0.001$). Men had a 4–6 times higher prevalence of abdominal aortic aneurysm than did women, depending on the definition of abdominal aortic aneurysm (table 1).

The mean age and age-adjusted characteristics of men and women with and without abdominal aortic aneurysm are summarized in table 2. In both men and women, age and age-adjusted mean levels of waist/hip ratio, serum HDL cholesterol, serum triglycerides, plasma fibrinogen, white blood cell count, previous or present use of antihypertensive medication, physical activity in leisure time during the last

TABLE 1. Percentage of subjects with abdominal aortic aneurysm, maximal aortic diameter of >29 mm, and maximal aortic diameter of >39 mm by sex and age, The Tromsø Study, 1994–1995

Age group (years)	No. of subjects examined		Abdominal aortic aneurysm*		Maximal aortic diameter of >29 mm		Maximal aortic diameter of >39 mm	
	Men	Women	Men (%)	Women (%)	Men (%)	Women (%)	Men (%)	Women (%)
25–44	214	282	0	0	0	0	0	0
45–54	156	199	2.6	0.5	1.9	0	0	0
55–64	1,394	1,477	6.2	0.7	6.0	1.1	1.1	0.1
65–74	1,117	1,370	14.1	4.2	12.8	2.8	4.1	0.7
75–84	81	96	19.8	5.2	18.5	4.2	8.6	1.0
Total	2,962	3,424	8.9	2.2	8.2	1.7	2.3	0.4

* "Abdominal aortic aneurysm" was defined as a renal aortic diameter of ≥35 mm, an infrarenal aortic diameter of ≥5 mm larger than the renal level, or localized infrarenal dilation of the aorta.

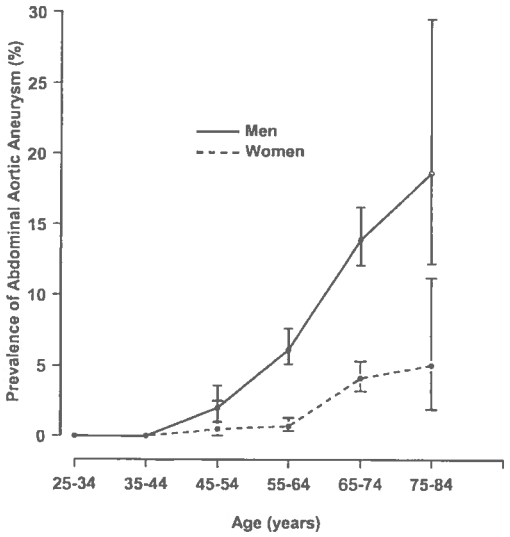

FIGURE 2. Prevalence of abdominal aortic aneurysm according to age and gender with 95% confidence intervals (bars), The Tromsø Study, 1994–1995.

year, and smoking were statistically significantly associated with abdominal aortic aneurysm. The mean weight, body mass index, serum total cholesterol, and serum creatinine were statistically significantly associated with abdominal aortic aneurysm in men only. Blood pressure was associated with the risk of abdominal aortic aneurysm in women only. In both men and women, there was no statistically significant association between the risk of abdominal aortic aneurysm and height, HbA_{1c}, and blood platelet count.

In the multivariate model, we included variables found to be associated with the risk of abdominal aortic aneurysm with $p < 0.1$ after adjustment for age in either sex. Two variables were not, however, included: weight (correlated with body mass index, $r = 0.77$) and diastolic blood pressure (correlated with systolic blood pressure, $r = 0.72$). Systolic blood pressure and ever use of antihypertensive medication were moderately correlated ($r = 0.26$ (men) and $r = 0.37$ (women)) and were both included in the model.

The risk of abdominal aortic aneurysm increased strongly with age in the multivariate model (table 3). The waist/hip ratio was positively related to the risk of abdominal aortic aneurysm. The point estimate was higher in women but not statistically significantly different from that in men ($p > 0.2$). High serum total cholesterol was a relatively weak risk factor for abdominal aortic aneurysm, whereas high HDL cholesterol was strongly associated with a low risk of abdominal aortic aneurysm in both genders. We found that systolic blood pressure was a risk factor in women only ($p < 0.001$). As the risks of abdominal aortic aneurysm for previous and current use of antihypertensive medication were similar (results not shown), the two dichotomous variables were combined. Ever use of antihypertensive medication was associated with increased risk of abdominal aortic aneurysm in both genders (table 3) even when adjusted for current systolic blood pressure. The effect of ever use of antihypertensive medication was found in both low (systolic blood pressure of <140 mmHg) and high (systolic blood pressure of ≥140 mmHg) blood pressure groups in both genders. We found no relation between pulse pressure and the risk of abdominal aortic aneurysm (results not shown).

Smoking, particularly current smoking, was a strong risk factor for abdominal aortic aneurysm in both genders, with a 6–7 times increased risk of abdominal aortic aneurysm in current smokers. In men, a high plasma fibrinogen level and a low blood platelet count increased the risk of abdominal aortic aneurysm significantly. Nonfasting serum triglycerides were not associated with the risk of abdominal aortic aneurysm in the multivariate model, and the association between the level of serum triglycerides and abdominal aortic aneurysm prevalence in the age-adjusted analysis was entirely explained by the inverse correlation ($r = -0.41$) with HDL cholesterol (results not shown). Body mass index, serum creatinine, white blood cell count, and physical activity in leisure time were not statistically significantly associ-

TABLE 2. Age and age-adjusted characteristics of men and women with and without an abdominal aortic aneurysm, The Tromsø Study, 1994–1995*

Risk factor	Aneurysm of the abdominal aorta					
	Men			Women		
	Aneurysm present (n = 263)	Aneurysm absent (n = 2,699)	p value	Aneurysm present (n = 74)	Aneurysm absent (n = 3,350)	p value
Age (years)	66.4 (6.1)	60.8 (10.0)	<0.001	69.4 (5.4)	61.2 (10.2)	<0.001
Height (cm)	175.2 (6.5)	175.1 (6.8)	0.7	162.1 (4.9)	161.5 (6.3)	0.4
Weight (kg)	81.7 (12.8)	79.4 (11.8)	0.003	67.8 (12.9)	67.6 (11.7)	0.9
Body mass index (kg/m²)	26.6 (3.7)	25.9 (3.3)	0.001	25.8 (4.6)	25.9 (4.4)	0.7
Waist/hip ratio	0.94 (0.06)	0.92 (0.06)	<0.001	0.85 (0.08)	0.82 (0.07)	<0.001
Serum cholesterol (mmol/liter)	6.65 (1.13)	6.47 (1.19)	0.02	7.02 (1.38)	6.93 (1.34)	0.5
Serum HDL† cholesterol (mmol/liter)	1.28 (0.37)	1.42 (0.39)	<0.001	1.46 (0.42)	1.68 (0.43)	<0.001
Serum triglycerides (mmol/liter)	1.97 (1.07)	1.75 (1.12)	0.002	1.89 (1.39)	1.56 (0.94)	0.003
HbA_{1c}† (%)	5.48 (0.65)	5.47 (0.67)	0.7	5.56 (0.57)	5.48 (0.64)	0.4
Serum creatinine (mmol/liter)	91.1 (23.4)	87.8 (22.3)	0.02	71.9 (13.0)	70.2 (12.9)	0.3
Plasma fibrinogen (mmol/liter)	3.72 (0.91)	3.32 (0.88)	<0.001	3.77 (0.68)	3.43 (0.80)	<0.001
Blood platelet count (10^9/liter)	232.8 (47.9)	239.4 (58.4)	0.08	255.4 (57.4)	256.0 (59.7)	0.9
White blood cell count (10^9/liter)	7.43 (1.84)	7.01 (1.92)	<0.001	7.69 (1.95)	6.78 (1.78)	<0.001
Diastolic blood pressure (mmHg)	83.9 (13.1)	82.6 (12.0)	0.09	82.1 (13.0)	79.1 (12.8)	0.04
Systolic blood pressure (mmHg)	143.4 (22.6)	142.4 (20.3)	0.4	151.3 (25.5)	141.4 (23.9)	<0.001
Antihypertensive medication (previous or present) (%)	29.1	17.4	<0.001	36.8	18.0	<0.001
Physical activity in leisure (%)	57.4	66.0	0.006	40.8	52.3	0.05
Previous smoking (%)	41.8	48.9	0.03	17.4	26.0	0.1
Current smoking (%)	51.6	31.6	<0.001	65.6	30.2	<0.001

* Values are means with standard deviation in parentheses or percentages.
† HDL, high density lipoprotein; HbA_{1c}, glycated hemoglobin.

ated with the risk of abdominal aortic aneurysm in either gender in the multivariate analysis.

There was a strong inverse association between serum HDL cholesterol levels and the prevalence of abdominal aortic aneurysm. A dose-response relation was found between the levels of serum HDL cholesterol (categorzed as <1.20 (reference), 1.20–1.39, 1.40–1.59, 1.60–1.79, and >1.79 mmol/liter) and the prevalence of abdominal aortic aneurysm in both men and women ($p < 0.001$). The multivariate-adjusted odds ratios for abdominal aortic aneurysm with serum HDL cholesterol concentrations were 0.72 (95 percent confidence interval (CI): 0.53, 0.99), 0.45 (95 percent CI: 0.31, 0.67), 0.51 (95 percent CI: 0.34, 0.77), and 0.33 (95 percent CI: 0.22, 0.51) when comparing with the reference group (HDL cholesterol of <1.20 mmol/liter). Analysis both with and without serum triglycerides was performed. Notably, this did not change the results with regard to HDL cholesterol.

Smoking was strongly associated with the risk of abdominal aortic aneurysm. The duration of smoking (not the number of cigarettes smoked per day) was the most important smoking variable associated with increased risk of abdominal aortic aneurysm. There was a strong linear dose-response relation with an increasing duration of smoking ($p < 0.001$). When comparing never smokers with those having a smoking duration of 1–20, 21–30, 31–40, and >40 years, we found that the multivariate-adjusted odds ratio for abdominal aortic aneurysm increased from 1.4 (95 percent CI: 0.8, 2.4) (1–20 years) to 8.0 (95 percent CI: 5.0, 12.6) (>40 years) when never smokers were the reference group. When adjusted for duration of smoking, there were no significant associations between the number of cigarettes smoked per day and the risk of abdominal aortic aneurysm (results not shown). Smoking measured as pack-years was significantly associated with the risk of abdominal aortic aneurysm in both genders, but the association was entirely explained by the duration of smoking (results not shown). The risk of abdominal aortic aneurysm decreased slowly after the cessation of smoking, and the reduction in risk was mainly due to the reduced duration of smoking. When adjusting for smoking duration, the risk of abdominal aortic aneurysm even 20 years after the cessation of smoking was not statistically significantly different from the risk for current smokers.

Subjects with abdominal aortic aneurysm were more likely to have a self-reported history of myocardial infarction, angina pectoris, or hypertension, but no relations were found with self-reported diabetes mellitus, asthma, or stroke (results not shown).

In a subgroup analysis, we included 2,336 men and 2,998 women who reported no history of myocardial infarction, angina pectoris, stroke, or diabetes. There were 158 men and

TABLE 3. Multivariate-adjusted odds ratio for abdominal aortic aneurysms in men and women, The Tromsø Study, 1994–1995

Risk factor	Men			Women		
	Odds ratio*	95% CI†	*p* value	Odds ratio	95% CI	*p* value
Age group (years)						
25–54	0.21	0.07, 0.59	0.004	0.31	0.04, 2.61	0.3
55–59	0.89	0.55, 1.42	0.6	0.24	0.05, 1.17	0.08
60–64	1.0	Reference		1.0	Reference	
65–69	2.18	1.44, 3.29	<0.001	1.94	0.81, 4.65	0.14
70–74	2.29	1.49, 3.52	<0.001	4.81	2.14, 10.84	<0.001
75–84	3.31	1.62, 6.73	0.001	4.98	1.45, 17.07	0.01
Body mass index (4 kg/m^2)	1.14	0.94, 1.39	0.19	0.85	0.65, 1.11	0.23
Waist/hip ratio (0.1)	1.12	0.86, 1.44	0.4	1.48	1.04, 2.10	0.03
Serum total cholesterol (1 mmol/liter)	1.19	1.04, 1.35	0.009	1.18	0.96, 1.44	0.11
Serum HDL† cholesterol (0.5 mmol/liter)	0.63	0.50, 0.79	<0.001	0.57	0.39, 0.85	0.005
Serum triglycerides (1 mmol/liter)	0.96	0.82, 1.12	0.6	0.97	0.73, 1.30	0.8
Serum creatinine (20 mmol/liter)	1.03	0.94, 1.12	0.6	1.00	0.72, 1.39	0.9
Plasma fibrinogen (1 mmol/liter)	1.42	1.22, 1.67	<0.001	1.23	0.91, 1.66	0.18
Blood platelet count (50.10^9/liter)	0.81	0.70, 0.94	0.005	0.86	0.66, 1.11	0.23
White blood cell count (2.10^9/liter)	1.04	0.88, 1.23	0.6	1.32	0.96, 1.83	0.09
Systolic blood pressure (20 mmHg)	0.97	0.85, 1.12	0.7	1.39	1.11, 1.73	0.004
Physical activity in leisure (yes/no)	0.80	0.61, 1.07	0.13	0.79	0.47, 1.35	0.4
Antihypertensive medication (current or previous) (yes/no)	1.61	1.16, 2.24	0.004	2.02	1.14, 3.57	0.02
Smoking						
Never smokers	1.0	Reference		1.0	Reference	
Previous smokers	3.60	1.85, 7.03	<0.001	1.64	0.75, 3.58	0.2
Current smokers	7.37	3.70, 14.69	<0.001	5.82	2.92, 11.58	<0.001

* Odds ratio with 95% confidence intervals and *p* values are derived from multiple logistic model analysis separately for each gender.
† CI, confidence interval; HDL, high density lipoprotein.

49 women with abdominal aortic aneurysm. The results from this stratified analysis confirmed the strong associations of serum HDL cholesterol and smoking with the risk of abdominal aortic aneurysm in both genders, with plasma fibrinogen and blood platelet count in men, and with systolic blood pressure in women. The impact of physical activity in leisure time in men was somewhat stronger in this stratified analysis (odds ratio = 0.64; 95 percent CI: 0.45, 0.92).

DISCUSSION

Most previous studies on abdominal aortic aneurysm were performed among middle-aged and elderly men. Our study covered all men and women aged 55–74 years and random 5–10 percent samples of subjects aged 25–54 and 75–84 years. We confirm that abdominal aortic aneurysm is a disease with a more than four times higher prevalence in men than women and that the prevalence increases with age (10, 15).

The complex pathogenesis of abdominal aortic aneurysm is still under debate. Conventionally, the development of abdominal aortic aneurysm has been attributed to atherosclerotic degeneration of the vessel wall (21). Atherosclerosis may increase the pressure load on the vessel and decrease the capacity of the wall to bear that load, leading to the formation of an abdominal aortic aneurysm (17). Louwrens et al. (19) concluded, however, that dilating and stenosing diseases are two distinct pathologic entities. Our results indicate that the risk factors for the development of abdominal aortic aneurysm and atherosclerosis are overlapping, but they should be confirmed in a prospective study design.

All aneurysms included in our analysis were previously unknown. Thus, knowledge of abdominal aortic aneurysm has probably not influenced the risk factor levels, although some persons may have been aware of the high risk of cardiovascular diseases and changed their living habits accordingly. The results were, however, unchanged when we restricted the analysis to subjects without known cardiovascular diseases. If an abdominal aortic aneurysm persists over years, it will cause turbulence of the blood flow, which may stimulate the blood platelets and the coagulation system.

Thus, the existence of an abdominal aortic aneurysm may have increased fibrinogen and reduced blood platelet count. The increased plasma fibrinogen in subjects with abdominal aortic aneurysm may reflect this. A direct relation cannot, however, be excluded.

A striking finding in the present study is the highly significant relation between low HDL cholesterol and the risk of abdominal aortic aneurysm. Similar and less pronounced relations have been found in some (9, 18, 25, 31, 33), but not all (13), previous studies. The risk of having an abdominal aortic aneurysm was 70 percent lower in subjects with a serum HDL cholesterol level of >1.79 mmol/liter compared with subjects with a serum HDL cholesterol level of <1.20 mmol/liter. It seems therefore likely that a low serum HDL cholesterol level, as a part of the atherogenic process, is a risk factor for developing an abdominal aortic aneurysm.

The blood sample was nonfasting, which has influenced the serum triglyceride level. As the misclassification is nondifferential, this has attenuated any relation between serum triglycerides and the risk of abdominal aortic aneurysm. In the multivariate analysis (table 3), we found no relation between the serum triglyceride level and abdominal aortic aneurysm risk.

Smoking is strongly associated with the risk of abdominal aortic aneurysm (table 3). The duration of smoking was the most important smoking variable associated with the risk of abdominal aortic aneurysm. The number of cigarettes per day or pack-years were not statistically significantly associated with abdominal aortic aneurysm risk when adjusted for duration. Cessation of smoking reduces the risk of abdominal aortic aneurysm slowly and mainly due to the reduced duration of smoking. The present findings are in accordance with those reported by Wilmink et al. (23) in a nested case-control study and several previous studies (9, 11, 16, 17, 25–27, 41, 42), but, in a recent population-based study by Vardulaki et al. (30), the level of cigarette use was reported as a stronger risk indicator than was duration of smoking.

It is at present not clarified whether hypertension increases the risk of abdominal aortic aneurysm (13, 14, 16, 24, 25, 27, 30, 34, 35). We found a significant relation between systolic blood pressure and abdominal aortic aneurysm in women but not in men. Ever use of antihypertensive medication was significantly associated with the risk of abdominal aortic aneurysm in both genders in our study, which supports a role of hypertension, as the use of antihypertensive medication probably is a proxy measure for long-term hypertension.

Some previous reports have indicated that the diameter of the abdominal aorta increases throughout life (43, 44). Recently, it has been suggested that the diameter of the infrarenal aorta increases only in a part of the population (45). As we do not have longitudinal data, we are not able to address this question properly. However, as the median maximal infrarenal aortic diameter increases only marginally with age from the age of 55 years, our data may give some support to the notion that a substantial increase in diameter with increasing age is found in a minority of the population. The 75th percentile does, however, increase considerably with age in men. Therefore, this minority cannot be negligible.

Because of the different criteria used for the definition of abdominal aortic aneurysm, it is difficult to compare the prevalence of abdominal aortic aneurysm in different epidemiologic studies. In the present study, the criteria for the diagnosis were set to give a high sensitivity for finding an abdominal aortic aneurysm. In spite of this, we found no persons with abdominal aortic aneurysm who were aged less than 48 years. As shown in table 1, the prevalence of abdominal aortic aneurysm in men was reduced from 8.9 percent to 8.2 percent and 2.3 percent if the criteria are set to >29 mm or >39 mm of maximal infrarenal aortic diameter, respectively. In women, the abdominal aortic aneurysm prevalence was reduced from 2.2 percent to 1.7 percent and 0.4 percent, respectively, if the criteria are similarly altered. In order to compare the prevalence of abdominal aortic aneurysm from different studies, it is important that the criteria for diagnosis are given and that the measurements of the abdominal aorta are done with a high degree of precision.

In our study, the attendance rate was relatively high as the aortic diameter was measured in 79 percent of the eligible persons. However, the attendance rate in the 25–44 and 75–84 year age groups was 62 percent and 58 percent, respectively. Although the overall attendance rate is higher than in most of the published studies, still a significant number did not attend the survey. Under the age of 55 years (with a total attendance rate of 71 percent), abdominal aortic aneurysms are very rare in our population, and the low number of invited subjects precludes a more detailed analysis of possible nonresponse bias. However, such bias should not influence our finding of a low prevalence.

The majority of our subjects were aged 55–74 years. The subjects who came to the first screening of the study, but did not attend ultrasound examination, had slightly higher levels of some, but not all, cardiovascular risk factors (low HDL cholesterol and current smoking, but similar blood pressure and lower total cholesterol) than those who attended the ultrasound examination (results not shown). However, because only 11 percent of those who attended the first screening did not attend the ultrasound examination, the mean values of risk factors were very similar in those who were examined with ultrasound and those who attended the first screening only. The major possible nonresponse bias is thus connected to the 9 percent of the eligible persons who never were examined. We find it unlikely that this relatively small group of subjects can seriously bias our findings.

The lower attendance rate by subjects aged over 74 years is of some greater concern as this age group has the highest prevalence of abdominal aortic aneurysm. However, the number of subjects invited was low, and the confidence intervals were wide. Thus, bias can hardly change the finding of a high prevalence of abdominal aortic aneurysm in old people, and the relatively few subjects included in these age groups cannot materially influence the analysis of risk factors for abdominal aortic aneurysm.

In conclusion, our study shows that abdominal aortic aneurysm is a disease of the elderly that is 4–6 times more prevalent among men than women. Tobacco smoking and low concentrations of serum HDL cholesterol are strong independent risk factors for abdominal aortic aneurysm in

both genders. Our results also indicate a significant effect of blood pressure on the risk of developing abdominal aortic aneurysm.

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REFERENCES

1. Basnyat PS, Biffin AHB, Moseley LG, et al. Mortality from ruptured abdominal aortic aneurysm in Wales. Br J Surg 1999; 86:765–70.
2. Samy AK, Whyte B, MacBain G. Abdominal aortic aneurysm in Scotland. Br J Surg 1994;81:1104–6.
3. Pleumeekers HJCM, Hoes AW, van der Does E, et al. Epidemiology of abdominal aortic aneurysms. Eur J Vasc Surg 1994;8:119–28.
4. Scott RAP, Tisi PV, Ashton HA, et al. Abdominal aortic aneurysm rupture rates: a 7-year follow-up of the entire abdominal aortic aneurysm population detected by screening. J Vasc Surg 1998;28:124–8.
5. Jaakkola P, Hippelainen M, Oksala I. Infrarenal aortofemoral bypass surgery: risk factors and mortality in 330 patients with abdominal aortic aneurysm or aortoiliac occlusive disease. Ann Chir Gynaecol 1996;85:28–35.
6. Aune S, Amundsen S, Evjensvold J, et al. Operative mortality and long-term relative survival of patients operated on for abdominal aortic aneurysm. Eur J Vasc Endovasc Surg 1995;9: 293–8.
7. Cao P, Rango PD. Abdominal aortic aneurysms: current management. Cardiologica 1999;44:711–17.
8. Collin J, Araujo L, Walton J, et al. Oxford screening programme for abdominal aortic aneurysm in men aged 65 to 74 years. Lancet 1988;2:613–15.
9. Alcorn HG, Wolfson SK, Sutton-Tyrell K, et al. Risk factors for abdominal aortic aneurysms in older adults enrolled in the Cardiovascular Health Study. Arterioscler Thromb Vasc Biol 1996;16:963–70.
10. Bengtsson H, Sonesson B, Bergqvist D. Incidence and prevalence of abdominal aortic aneurysms, estimated by necropsy studies and population screening by ultrasound. Ann N Y Acad Sci 1996;800:1–24.
11. Krohn CD, Kullmann G, Kvernbo K, et al. Ultrasonographic screening for abdominal aortic aneurysm. Eur J Surg 1992; 158:527–30.
12. Lucarotti M, Shaw E, Poskitt K, et al. The Gloucestershire aneurysm screening programme: the first 2 years' experience. Eur J Vasc Surg 1993;7:397–401.
13. Pleumeekers HJCM, Hoes AW, van der Does E, et al. Aneurysms of the abdominal aorta in older adults. The Rotterdam Study. Am J Epidemiol 1995;142:1291–9.
14. Smith FCT, Grimshaw GM, Paterson IS, et al. Ultrasonographic screening for abdominal aortic aneurysm in an urban community. Br J Surg 1993;80:1406–9.
15. Scott RAP, Ashton HA, Kay DN. Abdominal aortic aneurysm in 4237 screened patients: prevalence, development and management over 6 years. Br J Surg 1991;78:1122–5.
16. Lederle FA, Johnson GR, Wilson SE, et al. Prevalence and associations of abdominal aortic aneurysm detected through screening. Ann Intern Med 1997;126:441–9.
17. Dobrin PB. Pathophysiology and pathogenesis of aortic aneurysms. Surg Clin North Am 1989;69:687–703.
18. Blan AD, Devine C, Amiral J, et al. Soluble adhesion molecules, endothelial markers and atherosclerosis risk factors in abdominal aortic aneurysm: a comparison with claudicants and healthy controls. Blood Coagul Fibrinolysis 1998;9:479–84.
19. Louwrens HD, Adamson J, Powell JT, et al. Risk factors for atherosclerosis in men with stenosing or aneurysmal disease of the abdominal aorta. Int Angiol 1993;12:21–4.
20. MacSweeney STR, Powell JT, Greenhalgh RM. Pathogenesis of abdominal aortic aneurysm. Br J Surg 1994;81:935–41.
21. Reed D, Reed C, Stemmermann G, et al. Are aortic aneurysms caused by atherosclerosis? Circulation 1992;85:205–11.
22. Tilson D. Aortic aneurysms and atherosclerosis. Circulation 1992;85:378–9.
23. Wilmink TBM, Quick CRG, Day NE. The association between cigarette smoking and abdominal aortic aneurysms. J Vasc Surg 1999;30:1099–105.
24. Strachan DP. Predictors of death from aortic aneurysm among middle-aged men: the Whitehall Study. Br J Surg 1991;78: 401–4.
25. Naydeck BL, Sutton-Tyrell K, Schiller KD, et al. Prevalence and risk factors for abdominal aortic aneurysm in older adults with and without isolated hypertension. Am J Cardiol 1999; 83:759–64.
26. Simoni G, Pastorino C, Perrone R, et al. Screening for abdominal aortic aneurysms and associated risk factors in a general population. Eur J Vasc Endovasc Surg 1995;10:207–10.
27. Vazquez C, Sakalihasan N, D'Harcour J, et al. Routine ultrasound screening for abdominal aortic aneurysm among 65- and 75-year-old men in a city of 200,000 inhabitants. Ann Vasc Surg 1998;12:544–9.
28. Blicher. Haandbibliothek for Lœger. Forelesninger over Chirurgien av Asthley Cooper. Første deel. (In Danish). Copenhagen, Denmark: Fred Høsts Forlag, 1840.
29. Franks PJ, Edwards RJ, Greenhalgh RM, et al. Risk factors for abdominal aortic aneurysms in smokers. Eur J Vasc Endovasc Surg 1996;11:487–92.
30. Vardulaki KA, Walker NM, Day NE, et al. Quantifying the risks of hypertension, age, sex and smoking in patients with abdominal aortic aneurysm. Br J Surg 2000;87:195–200.
31. McConathy WJ, Alaupovic P, Woolcock N, et al. Lipids and apolipoprotein profiles in men with aneurysmal and stenosing aorto-iliac atherosclerosis. Eur J Vasc Surg 1989;3:511–14.
32. Watt HC, Law MR, Wald NJ, et al. Serum triglycerides: a possible risk factor for ruptured abdominal aortic aneurysm. Int J Epidemiol 1998;27:949–52.
33. Simoni G, Gianotti A, Ardia A, et al. Screening study of abdominal aortic aneurysm in a general population: lipid parameters. Cardiovasc Surg 1996;4:445–8.
34. Lindholt JS, Henneberg EW, Fasting H, et al. Mass or high-risk screening for abdominal aortic aneurysm. Br J Surg 1997; 84:40–2.
35. O'Kelly TJ, Heather BP. General practice-based population screening for abdominal aortic aneurysms: a pilot study. Br J Surg 1989;76:479–80.
36. Wilmink ABM, Quick CRG. Epidemiology and potential for prevention of abdominal aortic aneurysm. Br J Surg 1998;85: 155–62.
37. Bønaa KH, Arnesen E. Association between heart rate and atherogenic blood lipid fractions in a population. The Tromsø Study. Circulation 1992;86:394–405.
38. Knutsen SF, Knutsen R. The Tromsø Heart Study: family approach to intervention on CHD. Feasibility of risk factor reduction in high-risk persons—project description. Scand J Soc Med 1989;17:109–19.
39. Singh K, Bønaa KH, Solberg S, et al. Intra- and interobserver variability in ultrasound measurements of abdominal aortic

diameter. The Tromsø Study. Eur J Vasc Endovasc Surg 1998; 15:497–504.
40. SAS Institute, Inc. SAS/STAT user's guide. Cary, NC: SAS Institute, Inc, 1988.
41. Doll R, Peto R, Wheatley K, et al. Mortality in relation to smoking—40 years observations on male British doctors. BMJ 1994;309:901–11.
42. Lee A, Fowkes F, Carson M, et al. Smoking, atherosclerosis and risk of abdominal aortic aneurysm. Eur J Surg 1997;18:671–6.
43. Horjes D, Gilbert PM, Burstein S, et al. Normal aortoiliac diameters by CT. J Comput Assist Tomogr 1988;12:602–3.
44. Dixon AK, Lawrence JP, Mitchell J. Age-related changes in the abdominal aorta shown by computed tomography. Clin Radiol 1984;35:33–7.
45. Wilmink ABM, Pleumeekers HJCM, Hoes AW, et al. The infrarenal aortic diameter in relation to age: only part of the population in older age groups shows an increase. Eur J Vasc Endovasc Surg 1998;16:431–7.

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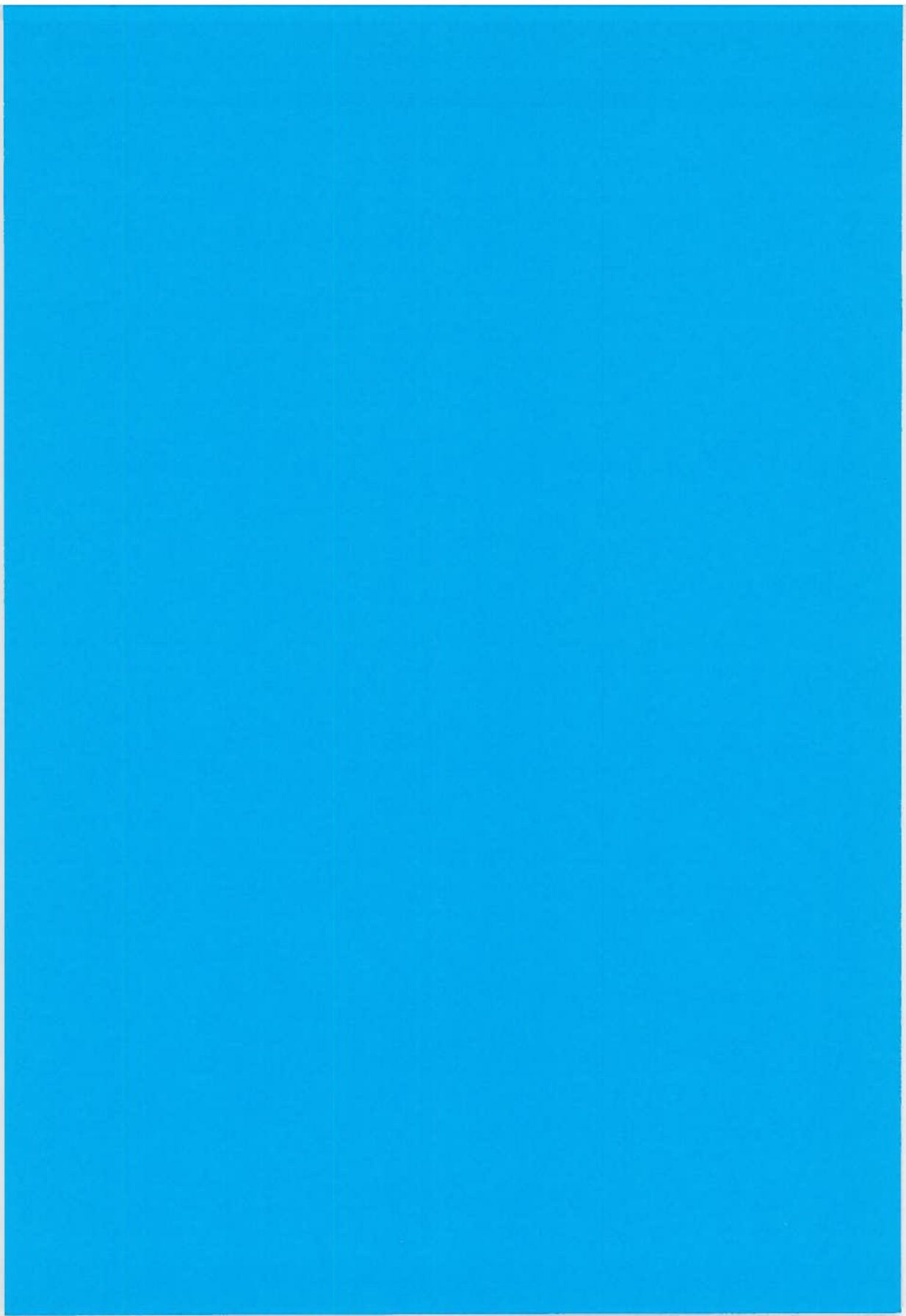

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Increased Growth Rate of Abdominal Aortic Aneurysms in Women. The Tromsø Study

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Objectives. *The present study was undertaken in order to assess the effect of gender on the growth rate of abdominal aortic aneurysms (AAAs).*
Methods. *One hundred and eighty-five men and 49 women with AAAs were studied, mean follow-up 62 months, giving 14,544 patient-months of follow-up. A mean of 16 ultrasound examinations was performed on each patient.*
Results. *The mean growth rate was 1.82; 1.65 and 2.43 mm per year in men and women, respectively. In a weighted linear regression analysis, high initial diameter and female gender were independent and significant ($p < 0.001$ and $p = 0.003$, respectively) predictors for increased growth rate of AAAs. None of the other considered risk factors predicted the growth rate.*
Conclusions. *This is the first study to report a significantly different growth rate of AAAs in females compared to males. It, thus, adds evidence to the view that AAA is a more malignant condition in females than in males and could have implications for the frequency of follow-up in women.*

Introduction

As early as the 1820s, Sir Asthley Cooper in London observed that aortic aneurysms (AAAs) were four times more prevalent in men than in women. This observation has been confirmed by more recent epidemiological studies.[1–4] Probably, due to this male predominance emphasis has been put on men in discussions and studies concerning AAA and several epidemiological studies have been undertaken with only men included. During the last few years, reports have appeared indicating that AAA in females may be more malignant than in men. Semmens and co-workers have found increased mortality following AAA rupture in women compared to men.[5] Further, increased operative mortality has been observed in both elective and acute surgery for AAA in women[6] and the rupture rate of AAAs has been found higher in women.[7,8] It has been observed that females, as compared with men, have more complications[9] and a higher rate of aborted stentgraft procedures.[10] Women also have a reduced long-term survival after open surgery for AAA.[11]

The risk of rupture of an AAA increases with increasing diameter of the aneurysm.[8] In accordance with a recent Cochrane-review, a maximal diameter of 55 mm or more, or a growth rate of 10 mm or more in 12 months are the common indications for interventional treatment of AAA.[12] However, a fast growth of AAA diameter as indication for repair has recently been questioned.[13] Patients with smaller AAAs, unwillingness for treatment or with serious co-morbidity are followed with serial ultrasound examination of the AAA.

As the maximum diameter of the AAA provides the basis for decisions regarding AAA repair, knowledge of the growth rate of AAAs is important. No previous study has focused on the growth rate of AAA in men compared to in women. The aim of the present report was, therefore, to address whether gender influenced the growth rate of AAA, in a study with 49 women and 185 men with AAA followed for up to 90 months.

All participants in the Tromsø study have signed an informed consent giving their approval for participation in the study and presentation of the results. The local committee for ethics approved the study.

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Materials and Methods

The Tromsø Study started in 1974 and is a population-based study with an emphasis on cardiovascular diseases. The fourth cross-sectional study started in September 1994 and was completed in October 1995 and included a questionnaire and ultrasonographic examination of the abdominal aorta. The detailed protocol for the part of this study regarding AAA has been presented.[4,14]

For the present study, the following information was of interest: all men and women aged 55–74 years and a sample of 5–10 per cent of other age groups in addition to some small subgroups of men and women were eligible for examination.[4] A total of 6892 persons had their abdominal aorta examined with a 3.5 MHz sector probe (Acuson 128-XP). AAA was diagnosed if one or more of the following three criteria was met: (1) a diameter of 35 mm or more at the level of the renal arteries, (2) a localised dilation of the infrarenal aorta or (3) an increase of the infrarenal aortic diameter of 5 mm or more compared to the level of the renal arteries in either transversal or anterior–posterior plane. If AAA or other pathology was found, the patients were referred to the Department of Cardiovascular Surgery and a computed tomography examination of the aorta. A total of 274 men and 74 women were found to have an AAA. Other pathology (e.g. three renal cancers) was found in 24 patients. Eight subjects had both an AAA and other significant pathology. One unrecognised pregnancy also was identified. The indication for surgery in this study was set at an aortic diameter of 55 mm or more.

Of the 348 patients with AAA, 14 did not attend CT-scan or a follow up. Due to the size of the AAA, 31 were operated upon in the initial phase of the study. In 47 persons, the CT-scan revealed non-aneurysmal abdominal aorta. Further, 22 patients with ultrasound detected AAA were either unwilling to participate in follow up, or moved to other parts of the country. The rest, 185 men and 49 women, were eligible for follow up and were followed with ultrasound examination of the abdominal aorta every third or sixth month from inclusion in the study in 1994–1995 to December 31, 2002. No patients withdrew from the study during follow-up. During follow-up, 49 patients were operated due to growth of the AAA and 48 patients died without surgery for their AAA. The follow-up time varied from 3 to 90 months with a mean of 62.4 months (59.6 months for women and 63.2 for men). Seven females and 38 males were followed for the maximum time period of 90 months. The number of ultrasound examinations varied from 2 to 31 with a mean of 16.1 examination (15.3 examinations for women and 16.3 for men). This yielded follow up of 14,544 patient–months with a total of 3773 ultrasound examinations, some performed by a radiologist but mostly by three trained and skilled sonographers. The reproducibility of the ultrasonographic examinations during the screening has been published.[14] Two of the three sonographers, using the same ultrasound machines as used for screening, performed the measurements of the AAAs in the follow-up study. The diameter of the AAAs as measured in the screening is used as the initial diameter for the present study.

The data were stored in an Access database. Calculations and organisation of the data were performed in Excel spreadsheet. Statistical calculations were performed in SAS and SPSS statistical packages. The change in diameter was assumed to be linear over time and modelled using ordinary linear regression analysis. The change in the diameter of the aneurysm for each person was estimated as the regression coefficient using time as the independent variable and diameter of AAA as the dependent variable. The time unit was set to 3 months, and this growth rate was then multiplied with four to give growth rate in mm per year. For the main analysis, a multiple regression analysis was performed. In a linear regression analysis, growth rate was the dependent variable and age, gender and start diameter as well as other risk factors for cardiovascular diseases were the independent variables. The analysis was weighted with the number of observations for each patient. When comparing means, *t*-test was performed and different variance between the groups was assumed. When comparing proportions Fisher's exact test was performed. Wilcoxon's rank test was used for non-parametric comparison of groups.

Results

The characteristics of the patients at the start of the follow-up period are given in Table 1. Adjustment for age did not notably change the *p*-values for the comparisons of men and women with AAAs (data not shown).

The overall mean growth rate (and standard deviation) was 1.82 (2.10) mm per year. The highest value was 16.0 mm per year. As shown in Table 2, the mean growth rate was 0.58 mm per year for AAAs with an initial diameter <25 and 2.63 mm for AAAs with initial diameter >49 mm.

The mean growth rate (and standard deviation) for women and men were 2.43 (2.95) and 1.65 (1.78) mm per year, respectively. The growth rates for both genders at the different levels of initial diameter are

Table 1. The characteristics of the patients at the start of the study

	Females	Males	*p*-value
N	49	185	
Initial age (years)	69.1 (5.6)	66.4 (6.3)	0.005
Mean initial diameter of AAA (mm)	31.9 (7.0)	35.5 (7.4)	0.002
Median initial diameter (min–max)	31 (22–55)	34 (25–85)	0.002
Systolic blood pressure (mmHg)	158.8 (25.2)	148.3 (21.8)	0.010
Diastolic blood pressure (mmHg)	85.7 (13.6)	86.2 (13.0)	0.9
Total cholesterol (mmol/l)	7.62 (1.30)	6.77 (1.15)	<0.001
HDL-cholesterol (mmol/l)	1.51 (0.43)	1.26 (0.33)	<0.001
Height (cm)	160.6 (4.6)	174.7 (6.8)	<0.001
Weight (kg)	67.0 (12.3)	81.6 (12.6)	<0.001
Body-mass index	26.0 (4.6)	26.7 (3.8)	0.3
Daily smokers	35/49 (71.4%)	88/184 (47.6%)	0.004
Angina pectoris	12/49 (24.5%)	53/184 (28.8%)	0.6
Cardiac infarction	7/49 (14.3%)	40/183 (21.9%)	0.3

The information is given as mean (and standard deviation), median or as proportions and percentages.

shown in Fig. 1. In the regression analysis, initial diameter and gender were both independent and significant predictors for the growth rate. Adjusted for age and initial diameter, the mean annual growth rate was 0.7 mm lower in men than in women ($p=0.003$), and adjusted for age and gender, the mean annual growth rate was 0.7 mm higher when the initial diameter increased 10 mm ($p<0.001$). Age at screening was not a significant predictor of the growth rate. The other characteristics and risk factors were also tested, but none was significant predictors for growth rate when start diameter, age and gender were included in the model.

For 10 patients, all men, the estimated growth rate was negative. The median initial diameter for these was 32.5 (31–52) mm. The median growth rate for these 10 patients was −0.38 (−8.0 to −0.03) mm per year. The lowest value was calculated in a patient with an AAA of 52 mm at the first examination, and after 3 months the diameter was assessed to be 50 mm. The patient expressed a preference for surgery and was not eligible for further measurements. In all the calculations and presentations in this paper, these 10 patients with a negative growth rate were included. Exclusion of these 10 patients did not alter significantly the results (data not shown).

The mean initial AAA diameter was 31.9 and 35.5 mm for women and men, respectively (Table 1). In the cross-sectional study,[4] the mean aortic diameter in 1370 females in the age group 65–74 years was 19.8 mm, and for the 1117 males in the same age group it was 23.7 mm. Thus, the initial diameter of the AAAs in the present study are 1.61 and 1.50 times greater in, women and men, respectively, than the mean diameter for this age group in the general population.

Discussion

To our knowledge, this is the first study examining formally the growth rates of AAA according to gender. Even if the number of females in the groups with the largest initial diameter was low, the difference between the growth rates according to gender was pronounced and highly significant. This study also confirms earlier findings that larger diameter AAAs grow faster.[15–17]

There are some reservations related to the methods used in this study. The calculations giving the growth rate in each patient assumes a linear growth of the aneurysms, whereas the growth of AAAs is exponential. Our results show that, the growth rate increases

Table 2. The mean growth rate (mm per year (standard deviation)) of the 234 AAAs according to start-diameter and gender

	All	Maximal diameter of aorta at start of follow-up						
		<25	25–29	30–34	35–39	40–44	45–49	>49
All								
Mean (SD)	1.82 (2.10)	0.58 (0.54)	1.19 (0.97)	1.80 (2.32)	1.75 (1.10)	2.31 (2.30)	3.36 (3.16)	2.63 (4.70)
N	234	3	43	87	58	23	11	9
Females								
Mean (SD)	2.43 (2.95)	0.58 (0.54)	1.47 (1.33)	2.75 (3.82)	2.01 (1.17)	5.94 (3.09)	7.01 (7.06)	6.80 (–)
N	49	3	17	15	9	2	2	1
Males								
Mean (SD)	1.65 (1.78)	–	1.01 (0.59)	1.60 (1.84)	1.70 (1.09)	1.96 (1.97)	2.55 (1.48)	2.11 (4.74)
N	185	0	26	72	49	21	9	8

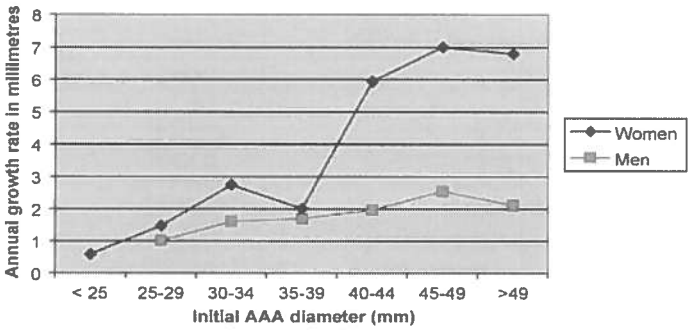

Fig. 1. The growth rate of AAA in 49 women and 185 men followed up to 90 months. In a regression analysis, both initial AAA diameter and female gender predicted the growth rate ($p<0.001$ and $p=0.003$, respectively).

with the diameter of the AAA. However, few patients had such high initial AAA diameter that the exponential and linear curves differed significantly. A relatively larger AAA in women compared to men could underlie the increased AAA growth rate observed in women. The mean diameter of the AAAs in the females was 1.61 times larger than the mean infrarenal aortic diameter in the normal population. In the males the diameter was 1.50 times higher. This difference is negligible and is unlikely to explain the difference in growth rate between the two genders. It also may be a cause of concern that we have only followed 234 of the 348 subjects who had an AAA diagnosed. However, the group of subjects who were followed did not differ significantly from the other subjects with regard to age or sex (data not shown). Most likely, the 10 negative values for growth rate in this cohort were the result of errors in the measurements.

The percentage of patients found to have an AAA in population studies varies with age and sex distribution of the population and the diagnostic criteria for inclusion, e.g. the diameter of the aorta.[4] The AAA growth rate also appears to depend on these same factors. In 1993, Bengtsson and co-workers found a growth rate of 3.1 mm per year and increased growth with increased diameter. Their study was based on 155 subjects with an AAA, 20–80 mm in diameter with both men and women included.[15] Similar growth rates and a correlation with growth rate and diameter has been confirmed in other studies.[17,18] Santilli and co-workers found a growth rate of 1.6 mm per year in men with initial AAA diameter of 30–39 mm.[17] This finding is identical with that for the same subgroup in our results (Table 2). Association of AAA growth rate with cardiac disease,[19] age and a history of cigarette smoking have been found.[18,20] In the present study, the participants' information on daily smoking at the start of the study did not predict the growth rate of the AAA. Stopping smoking has been found to reduce the growth.[21] We do not have information about smoking during the follow-up study.

The main finding of the present study; that AAA grow faster in women, adds evidence to the view that AAAs are more malignant in females than in men. This could have implications for AAA screening policies. Surveillance might need to be more frequent in women, compared with men, with an AAA diameter of more than 40 mm. However, we acknowledge that the number of women included in our study was low, and believe that our results ought to be confirmed in larger studies. However, since treatment of the AAAs in women may have more complications and a higher mortality than in men, there may be no indication for earlier intervention in women.

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References

1 Scott RA, Ashton HA, Kay DN. Abdominal aortic aneurysm in 4237 screened patients: prevalence, development and management over 6 years. *Br J Surg* 1991;78:1122–1125.
2 Simoni G, Pastorino C, Perrone R, Arida A, Gianrossi R, Decian F, Cittandini Jr G, Baiardi A, Bachi V. Screening for abdominal aortic aneurysms and associated risk factors in a general population. *Eur J Vasc Endovasc Surg* 1995;10:207–210.
3 Pleumeekers HJ, Hoes AW, van der Does E, van Urk H, Hofman A, de Jong PT, Grobbee DE. Aneurysms of the abdominal aorta in older adults. The Rotterdam study. *Am J Epidemiol* 1995;142:1291–1299.
4 Singh K, Bønaa KH, Jacobsen BK, Bjørk L, Solberg S. Prevalence of and risk factors for abdominal aortic aneurysms

in a population-based study. The Tromsø study. *Am J Epidemiol* 2001;154:236–244.
5 Semmens JB, Norman PE, Lawrence-Brown MM, Holman CD. Influence of gender on outcome from ruptured abdominal aortic aneurysm. *Br J Surg* 2000;87:191–194.
6 Dimick JB, Stanley JC, Axelrod DA, Kazmers A, Henke PK, Jacobs LA, Wakefield TW, Greenfield LJ, Upchurch Jr GR. Variation in death rate after abdominal aortic aneurysmectomy in the United States. Impact of hospital volume, gender, and age. *Ann Surg* 2002;235:579–585.
7 The UK Small Aneurysm Trial Participants. Long-term outcomes of immediate repair compared with surveillance for small abdominal aortic aneurysms. *N Engl J Med* 2002;346:1445–1452.
8 Brown PM, Zelt DT, Sobolev B. The risk of rupture in untreated aneurysms: the impact of size, gender, and expansion rate. *J Vasc Surg* 2003;37:280–284.
9 Wolf YG, Arko FR, Hill BB, Olcott 4th C, Harris Jr EJ, Fogarty TJ, Zarins CK. Gender differences in endovascular abdominal aortic aneurysm repair with the AneuRx stent graft. *J Vasc Surg* 2002;35:882–886.
10 Mathison M, Becker GJ, Katzen BT, Benenati JF, Zemel G, Powel A, Kovacs ME, Lima MM. The influence of female gender on the outcome of endovascular abdominal aortic aneurysm repair. *J Vasc Interv Radiol* 2001;12:1047–1051.
11 Stenbaek J, Granath F, Swedenborg J. Outcome after abdominal aortic aneurysm repair. Difference between men and women. *Eur J Vasc Endovasc Surg* 2004;28:47–51.
12 Ballard DJ, Fowkes FG, Powell JT. Surgery for small asymptomatic abdominal aortic aneurysms. *Cochrane Database Syst Rev*22000;:CD001835.
13 Sharp MA, Collin J. A myth exposed: fast growth in diameter does not justify precocious abdominal aortic aneurysm repair. *Eur J Vasc Endovasc Surg* 2003;25:408–411.
14 Singh K, Bønaa KH, Solberg S, Sørlie D, Bjørk L. Intra- and interobserver variability in ultrasound measurements of abdominal aortic diameter. The Tromsø Study. *Eur J Vasc Endovasc Surg* 1998;15:497–504.
15 Bengtsson H, Bergquist D, Ekberg O, Ranstam J. Expansion pattern and risk of rupture of abdominal aortic aneurysms that were not operated on. *Eur J Surg* 1993;159:461–467.
16 Stonebridge PA, Draper T, Kelman J, Howlett J, Allan PL, Prescott R, Ruckley CV. Growth rate of infrarenal aortic aneurysms. *Eur J Vasc Endovasc Surg* 1996;11:70–73.
17 Santilli SM, Littooy FN, Cambria RA, Rapp JH, Tretinyak AS, d'Audiffret AC, Kuskowski MA, Roethle ST, Tomczak CM, Krupski WC. Expansion rates and outcome for the 3.0 cm to the 3.9 cm infrarenal abdominal aortic aneurysm. *J Vasc Surg* 2002; 35:666–671.
18 Chang JB, Stein TA, Liu JP, Dunn ME. Risk factors associated with rapid growth of small abdominal aortic aneurysms. *Surgery* 1997;121:117–122.
19 Englund R, Hudson P, Hanel K, Stanton A. Expansion rates of small abdominal aortic aneurysms. *Aust N Z J Surg* 1998;68:21–24.
20 Brady AR, Thompson SG, Fowkes FG, Greenalgh RM, Powell JT. UK small aneurysm trial participants. *Circulation* 2004;110:16–21.
21 MacSweeney ST, Ellis M, Worrell PC, Greenalgh RM, Powell JT. Smoking and growth rate of small abdominal aortic aneurysms. *Lancet* 1994;334:651–652.

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1. Bidrag til belysning av medisinske og sosiale forhold i Finnmark fylke, med særlig vekt på forholdene blant finskættede i Sør-Varanger kommune.
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