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Long-term central venous catheters – characteristics and complications

A retrospective quality assurance study on complications related to central venous ports and Hickmann catheters inserted at the UNN Tromsø

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Preface

The idea of this project first came to mind in my third year in medicine in 2018 when I got told that this was a much-needed study, and highly valued work for the catheter unit at UNN Tromsø. It has been a long journey, but I am very satisfied with how it turned out.

Especially thanks to Lars Marius Ytrebø and Kristin Jensen for excellent guidance throughout this process, and for always giving me structured and clear feedback on the numerous drafts I have emailed. A much-obliged appreciation to Lars Marius for stepping up when we needed an extra supervisor, despite a very tight time schedule.

I am hoping that this paper will be the first of many quality-assuring studies regarding central venous catheters at UNN Tromsø. Hopefully, we will highlight some important aspects that will be interesting to further investigate for future students and researchers.

Hedda C Hanssen

Summary

Central venous catheters have become an important tool in modern health care and has an important role in many medical procedures and therapies such as administration of various intravenous medications, haemodynamic monitoring, and blood sampling. With this kind of procedure, the central venous catheter tip is placed in a vein near or within the right atrium using an ultrasound guided technique. However, short- and long-term complications may occur. In 2014 the “venous access” group, responsible for catheter insertion and follow-up, was established at UNN Tromsø. This group of clinicians was recruited from the Department of Anaesthesia and provides services to patients in Helse Nord. The main objective for this study was to obtain accurate quality data on central venous ports and Hickmann catheters inserted by the catheter unit staff at UNN Hf during 2017-2019. We specifically set out to investigate complication rates, catheter lifetime, and patency of all catheters inserted.

We retrospectively collected data from catheters inserted by the catheter unit from January 1st 2017 to December 31st 2019. Children and adults from the region of Troms and Finnmark were included in the study. Data of interest were demographic and patient-specific factors, procedural factors, and complications. All catheters were followed up until catheter endpoint, whether this was due to removal of the catheter, diseased patient or catheters still in use by the last date of data recording on March 31st 2022.

A total of 226 catheter insertions were included in this study, 153 central venous ports and 73 Hickman catheters. These were inserted in 209 adults and in 17 children. The main diagnosis in both children and adults were cancer, and chemotherapy was the main indication. Most complications occurred beyond 30 days (long-term). Malfunction, thrombosis, and infection were the most frequent complications. The overall complication rate was 0.8/1000 catheter days in ports and 2.7/1000 catheter days in Hickman catheters. Hickman catheters were more likely to be both malfunctioning and site of infection compared to central venous ports (p=0.002 and p=0.02, respectively). Biochemical findings did not always support removal in cases of catheter related infection, indication there is a low threshold for catheter removal amongst clinicians. Future research should aim to improve methods and reduce complications.

1 Introduction

1.1 Abbreviations

PVO	Personvernombudet (data protection officer)
TPN	Total parenteral nutrition
UNN	University hospital of North Norway
HF	Helseforetak (Health Trust)
DIPS	Electronic hospital record
K3K	Division of Surgery, Oncology and Women's health
CVC	Central Venous Catheter
TIVAP	Totally Implantable Central Venous Port
PICC-line	Peripherally Inserted Central Catheter line
MIDLINE	Medial Inserted Catheter
NPR-ID	National Patient Record Number
VAD	Venous access device
DVT	Deep Vein Thrombosis

1.2 Term clarifications

1. INDICATION: The reason the patient needs a central line access
2. UNSUCCESSFUL PROCEDURE: Defined as change of catheter insertion site due to difficulty to insert catheter in the first attempted vein.
3. CATHETER MALFUNCTION: Defined as infusion or aspiration difficulties with a need for either use of Alteplase for catheter removal. This includes cases of mechanical failure like line fracture, fragmentation of the catheter tip or clogged catheter.
4. THROMBUS FORMATION: Catheter thrombus confirmed by ultrasound or CT-scans.
5. INFECTION: Catheter removal due to local or systemic symptoms of infection or use of antibiotics due to a strong clinical suspicion of catheter related infection.
6. PNEUMOTHORAX: Confirmed by post-procedural chest x-ray.
7. HEMATOMA: Excessive swelling of visible blue coloration, in tissue around the implanted catheter.
8. IMMUNOSUPPRESSION: Defined as ongoing chemotherapy, use of prednisone or any other drug that is defined as an immunomodulator.

1.3 Background

1.3.1 What are central venous catheters and what purpose do they serve?

A central venous catheter (CVC) is a catheter that is placed with the tip positioned in a large central vein near the heart, such as the superior caval vein, the inferior caval vein, or in the right atrium. This venous access is achieved by inserting the catheters via the large veins in the upper body(internal jugular vein, subclavian vein) or in the groin (femoral vein), from where they subsequently, by various techniques, are inserted into the desired central venous location (1).

Central venous catheters are an important part of several medical therapies and procedures in modern health care. They are used for administration of various intravenous medications, haemodynamic monitoring, and blood sampling. They are commonly indicated in situations where peripheral venous access is deemed inadequate, or difficult to obtain, or when there is a need for long-term, reliable intravenous access(2). In addition, certain drugs (i.e. chemotherapy) and parenteral nutrition (TPN), cannot or should not be given peripherally due to risk of venous irritation and breakdown peripherally, and thus must be administered centrally (3).

1.3.2 Seldingers technique and catheter insertion site

The technique that often is used when placing a central venous line is Seldingers technique(4). This is a method that was developed by the Swedish radiologist Sven Ivar Seldinger in the 1950s and is based on the idea that you can access the body's veins and arteries in a gentle way by a needle puncture of the skin and vessel, instead of surgical cutdown. It is done by puncturing the desired vein or artery with a needle, and then insert a guidewire into the punctured vessel. Thereafter the needle is retracted, and the catheter is inserted into the vessel, over the guidewire. The guidewire is then removed when the catheter is in place. This has become a very important technique that is utilized in many medical procedures. It has provided a simple way of establishing secure intravenous access while minimizing patient trauma(5).

Decision on insertion site depends on several patient and clinical factors, which demands an individual assessment in each case. Examples are the operator's experience, anatomical and hemostatic variations, and ultrasound visibility of the target vessel. A good clinical assessment prior to procedure is mandatory in order to minimize the chances of procedure related complications (6).

1.3.3 Types of central venous catheters

There are currently several types of central venous catheters on the market, all of which hold different properties. Catheter of choice depends on indications and decisions must be taken in collaboration with the patient's and clinician's preferences. Factors taken into consideration are estimated catheter lifetime, the type of infusion/treatment, desired number of lumens and other patient-specific factors(2).

CVCs can be divided into three groups; 1. tunnelled catheters, 2. non-tunnelled catheters, and 3. totally implantable venous access ports (TIVAPs) where the entire catheter lies underneath the skin barrier(2).

Non-tunnelled catheters exit the skin at the site of vein puncture. A common indication for this catheter type is the need of a rapid, temporary central venous access, during surgery or during treatment in the intensive care unit. The site of insertion is usually the internal jugular vein or subclavian vein. A subgroup of catheters is named PICC-lines (peripherally inserted central catheter). They cover the same function as the non-tunneled CVCs, but can be placed via a peripheral vein on the upper limb, such as the basilica vein or the brachial vein (2).

Tunnelled catheters are different as the skin puncture site is located with some distance from the vein puncture site. This is achieved by making a subcutaneous tunnel from the vein puncture site to the chest wall where the catheter encounters the external environment. This offers several benefits, especially in terms of longer durability and lower infection risk. A Hickmann catheter is an example of this type of catheter (7).

Totally implantable venous ports implies that the catheter is implanted in its entirety underneath the skin. The distal part of the catheter has a port with a silicone membrane which is attached to the underlying muscle fascia and secured with sutures. The silicone membrane is punctured with the aid of a specialised needle when the catheter is used. While non-tunnelled catheters often need to be replaced after days or a few weeks, tunneled catheters can last up to several months and even years before they must be removed(7). For illustrations of central venous catheter and Hickman catheter, see figure 1.

1.3.4 Complications related to central venous ports and Hickman catheters

As with all medical procedures, as well as medical devices placed within the human body, there are adherent risk of complications. It is useful and quite common to divide complications into short-term complications (occurring within 30 days) and long-term complications (occurring beyond 30 days).

Short-term complications include unwanted procedure-related events, as well as other problems occurring within the first month of catheter insertion. Procedure related complications consist of suboptimal or incorrect catheter placement and arrythmias triggered by the guidewire or catheter itself. Other, more severe, procedure related complications are damage and puncture of nearby structures such as arteries, nerves, and lung parenchyma, which in a worst-case scenario can lead to pneumothorax or haemothorax. In order to minimise these risks, different imaging techniques are applied. Ultrasound and fluoroscopy used during the procedure, as well as chest x-ray increase success rate and safety(8).

Other, non-procedure related short-term complications may also occur. Catheter malfunction and difficulties with infusion and aspiration from the catheter is not unusual and can occur due to clamping of the catheter tube, thrombus formation in or around the catheter tip or an otherwise clogged catheter. Fragmentation of the catheter is especially undesirable due to the risk of embolization with subsequent heart tissue injury or occlusion of pulmonary arteries. The same applies to thrombosis around the catheter as this may decrease or even occlude venous drainage from the upper limb(8)

Catheter-related infections are also not uncommon. This was clearly demonstrated in a clinical study from India where bacteraemia originating from a central venous catheter was one of the most frequent triggers of blood-stream infections in hospitals (9). A catheter related infection can consist of a local tissue infection around the catheter insertion site or in the tunnelled pocket, or the infection can spread from the colonised catheter to the blood stream and cause systemic sepsis. Because of the elevated infection risk related to CVCs, and the fact that these infections can be very difficult to treat, most clinicians practice a low threshold for the removal of catheters in patients presenting with signs and symptoms of infection(10). This practice has in recent years been challenged by publications and recommendations suggesting a trial of antibiotics as first line management of suspected catheter related infection(11).

1.3.1 The catheter unit at UNN HF

The hospital of North Norway was first build in 1922. In 1969 the Norwegian parliament decided that the third university of the nation was to be established in Tromsø and alongside this decided to build a new hospital on the university ground. The new building was finalized in 1991, and today UNN Hf provides services to approximately 800 inpatients and 6000 employees (12). The history of CVC-insertion at UNN stretches back to the late 1960’s when the first anesthesiologist was employed. Long-term CVCs were first inserted in the early 1980’s. At this time, the main indication was the need for total parenteral nutrition (TPN) before and after abdominal surgery and malabsorption disorders, or hemodialysis (L. Bjertnes, personal communication May 6, 2022). As the procedure itself contains some surgical elements, and mainly involved patients in the surgical ward, it was reasonable to assign insertion of long-term catheters to surgeons.

Over the tears, indications and patients needing long-term CVCs were increasing, and it was therefore requested to establish a specialized group of operators responsible for catheter insertion. Hopefully, this would facilitate the workload on surgeons, and contribute to a higher number of procedures per operator and subsequently more experienced clinicians and better procedural quality (Ø. Irtun, personal communication, April 27, 2022).

The procedure of establishing central venous access and lines, now falls under the anesthetist’s scope of practice. In 2014 the “venous access” group was established at the hospital, as a subgroup of the anesthesia department. This group consists of specially trained anesthetists who together run a service providing long term central venous access to patients in the health region. This includes tunneled catheters and short-term CVCs. Midline catheters and PICC-line catheters are inserted by a specialized group of nurses (K. Jensen, personal communication, May 19, 2022)

Since the establishment of the catheter unit at UNN HF in 2014, no systematic assessment of the service, has been done. We wanted to investigate and elucidate the service's workload and outcomes, by gathering systematic data concerning patient characteristics, procedural factors, and various complication rates. This is an important part in the catheter sections continuous quality improvement activities and allows comparison with results from other similar services.

1.3.2 Aim of this study

The main objective for this study was to obtain accurate quality data on central venous ports and Hickmann catheters inserted by the catheter unit staff at UNN HF during 2017-2019. We specifically set out to investigate complication rates, catheter lifetime, and patency of all catheters inserted.

2 Materials and methods

2.1 Approvals

This study was approved by the data protection officer at UNN Tromsø and Hospital of Finnmark, respectively. Initially it was desirable to also get approval from Nordlandssykehuset, but due only 30 eligible patients and an intricate application process we decided to not include those patients. Consent was not required for this kind of clinical quality assurance studies.

2.2 Study design and patient selection

This study was designed as a retrospective quality assurance study of central venous ports and Hickman catheters inserted at the “catheter unit” UNN Tromsø from January 1^{st}, 2017, to December 31^{st}, 2019. Data was manually collected from the electronic hospital record system (DIPS). The total number of catheters included was 226, distributed in 195 adults and 16 children.

2.3 Inclusion and exclusion criteria

Adults and children (<18 years old) who electively received a central venous port or a Hickman catheter inserted by the catheter team members were eligible. However, a second criterion was that UNN Tromsø or Finnmarksykehuset served as their local hospital. This last criterion was assessed by the patients’ residential address. Each catheter insertion was counted as one procedure, which means that if a patient received more than one catheter during the specified period, we would count those as separate entities.

A systematic search in the electronic hospital record database would not return the correct number of procedures performed due to inconsistent coding of procedures. We therefore decided to manually search the elective operation lists to secure an accurate list of procedures performed.

For flow chart showing number of catheters included and excluded, see figure 2.

2.4 Variables

All patients were given an individual record number, which was linked to their national patient record number (NPR-ID). This made it easy to identify the patient whenever needed during the data analysis.

The following variables were recorded:

Demographics

Preoperative patient factors: Main diagnosis, indication, use of immunosuppressants/antithrombotic medications/antibiotics, blood-tests taken a week prior to procedure(haemoglobin, leukocytes, CRP, APTT, INR, thrombocytes), need of preoperative platelet infusion

Procedural factors: Operator performing procedure, use of prophylactic antibiotics, catheter type, catheter insertion site, use of fluoroscopy, needle in venous port post-procedure, unsuccessful procedure, heparin installed in catheter post-procedure, mispositioned catheter.

Complications short-term: Pneumothorax, infection, malfunction, thrombosis, hematoma others.

Complications long-term: Infection, malfunction, thrombosis, others.

In addition date of complication and cause of catheter end-point was recorded.

All catheters were followed up from date of insertion to catheter endpoint. The last recorded data was March 31st, 2022. I.e., catheters categorized as “still in use” were not yet removed at this date.

2.5 Statistical analysis

All data were analysed and collected in SPSS statistics version 28. Descriptive statistics was used to present and visualise demographic and categorical data. To analyse the independence between two categorical variables, a chi-square test was run when expected values were more than 5 in more than 80% of the cells. A Fisher’s exact test was used in smaller samples where expected values less than 5 accounted for more than 20% of the cells.

3 Results

During 2017-2019 a total of 225 procedures were performed and 226 catheters inserted. 153 central venous ports and 73 Hickman catheters in total. One adult had three catheters inserted and 12 had two catheters inserted (including one child).

3.1 Demographics

See table 1 for patient demographics by gender. For demographics by age, height, weight, and body mass index, see table 2.

3.2 Preoperative patient factors

For bar chart showing frequency of main diagnosis amongst adults, see figure 3.

Twelve out of the seventeen children had a cancerous diagnosis and five of those had a haematological malignancy diagnosis. The remaining five were diagnosed with non-malignant diseases.
Accordingly, cancer was the main diagnosis, accounting for 84% of all cases (children and adults).

Chemotherapy was the main indication for catheter insertion in both children and adults. See table 3 for complete distribution.

Indication «Others» represent three children who were in need for blood transfusions. Three adults needed blood products and further three adults received medications and fluids through a central venous access.

3.3 Procedural factors

Central venous ports were inserted in 68% of the total procedures performed in children and adults. See figure 4 for histogram showing frequencies of catheter type.

The most used insertion site was the right internal jugular vein, utilized in 63% of the total procedures. For frequencies of catheter insertion site in children and adults, see figure 5.

For boxplot showing procedural time in children and adults, see figure 6.
Procedural time is defined by looking at the anaesthesiologist journal where time from first puncture to completion of the last sutures is visualised by specific symbols.

All procedures were performed using Seldingers technique. No catheters were placed by surgical cutdown.

Use of fluoroscopy: Data from five patients were missing. However, fluoroscopy was documented applied in 94% of the remaining patients. Two procedures had to be performed in an interventional radiology lab due to difficult procedures.
Heparin post-procedure: 100 IU unfractionated heparin was installed in 97% of the procedures. Data from five cases were missing.
Operators: Eight people were performing the procedures. Number 9 represents one case performed by a doctor not part of the central venous catheter team in UNN Tromsø. See figure 7 for histogram showing number of catheters inserted per operator in adults, and figure 8 for histogram showing number of catheters inserted per operator in children.

The total median catheter lifetime (time in situ) were 197 days (range 2-1720) in central venous ports and 126 (range 0-1377) in all-lumen Hickman catheters. See figure 9 for boxplot showing number of catheter days per catheter type in children and adults.

3.4 Complications

The overall complication rate in central venous ports was 0.8/1000 catheter days. In Hickman catheters it was 2.7/1000 catheter days.

Short-term complication

Infection was the overall most common short-term complication, accounting for 34% of all complications detected. See table 4 for distribution of complications detected amongst children and adults.

The category «others» represent adult cases were catheter or port had to be removed. One adult patient due to catheter-related pain, three adults with TIVAPs detached from underlying surface and dislocated. One adult accidentally removed catheter. In an obese patient the venous port could not be localised after insertion, as the port was placed too deep and laterally on the thorax. A secondary procedure was necessary in order to optimize port position.

One serious procedure-related complication was recorded in one child (arterial puncture and haemothorax). Wound rupture was recorded in another child after central venous port procedure.

Pneumothorax: Pneumothorax was diagnosed in five patients. In three of these patients a chest drain was inserted. In the remaining two patients, pneumothorax resolved without any specific treatment. The median procedural time in the group that got a pneumothorax was 84 minutes (mean 97 minutes). The median patient BMI was 21.4 kg/m^2 (mean 22). Three of the five patients diagnosed with pneumothorax had previously had a central venous catheter inserted

Unsuccessful procedure: Data from two patients were missing. In the remaining cases, unsuccessful procedure was registered in 17 out of 226 procedures. In one patient the procedure had to be cancelled because of a serious procedure-related complication. In the remaining cases the catheters were successfully inserted after change of vascular insertion site.

long-term complications

Malfunction/thrombosis was the most common long-term complication and accounted for 63% of all complications detected amongst both children and adults. See table 5 for distribution of long-term complications in children and adults.

The category «other» represents one adult patient with catheter-related pain. Catheter was not removed but had to be repositioned as it was poorly fixated to the underlying muscle fascia. Data from 20 adults and three children were missing as catheter removal occurred before 30

Local and systemic infections in central venous ports and Hickman catheters

In central venous ports the incidence of catheter-related infection was 0.27/1000 catheter days and 0.94/1000 in Hickman catheters (local and systemic infection).

Central venous ports

See figure 10 for flow chart showing incidence and management of local and systemic infection in children and adults.

Fourteen cases of infection were diagnosed among adult patients who received a central venous port, which nine were diagnosed within 30 days and five diagnosed beyond 30 days. In children both cases were diagnosed within 30 days.

All six patients who kept their catheter despite catheter related infection, were successfully treated with antibiotics. There were no recordings of recurrent infection.

Catheter tip culture: None of the patients that got their catheter removed due to symptoms of systemic infection had positive catheter tip cultures. Four had positive blood cultures (three cases of Staphylococcus Epidermidis and one case of Staphylococcus Aureus).

In the three adults with local infection, one had colonisation of Staphylococcus Aureus, one had colonisation of Pseudomonas aeruginosa, and one had colonisation of Staphylococcus Epidermidis on the catheter tip.

Needle placed in port-chamber post-procedure: There were no differences in the incidence of short-term infection rate between patients who received the port needle during the procedure and those who received this needle at the ward (p=1.0).

Hickmann catheter

See figure 11 for flow chart showing incidence and management of infection amongst children and adults with Hickmann catheters.

Fifteen patients were diagnosed with infection. Two cases appeared within 30 days and 13 cases beyond 30 days. Four of the cases were diagnosed in patients with a single lumen

Hickman catheter, 10 cases in patients with a double lumen Hickman and one in a patient with a triple lumen Hickman catheter.
One child suffered from local infection in a double lumen Hickman catheter, which was not removed. He was successfully treated with antibiotics.

Out of the 14 patients that had their catheter removed due to a suspicion of catheter-related infection, four had colonization of bacteria on the catheter tip.

Catheter tip culture: One patient with systemic infection had colonization of Staphylococcus aureus and one had colonization of candida Albicans. Both had positive blood cultures with the same microbe. The two adults with local infection both had colonization of staphylococcus Aureus.

Hickmann catheters compared to ports

For crosstabulation showing the relationship between infection rate and pharmacological immunosuppression in children and adults with Hickmann catheters and ports, see table 6.

There was a significant increased likelihood of infection in patients receiving Hickman catheters (15/73) compared to central venous ports (14/153), ($X^2(1, N = 226)5.74, p = 0.017$). For the relationship between total infection rate in central venous ports and Hickmann catheters, see table 7.

Malfunction and thrombosis in central venous ports and Hickman catheters

In figure 12 incidence and management of malfunction is visualised in a flow chart. See table 8 for subgroups of Hickman catheters.

The distribution of central venous ports and Hickman catheters in total (children and adults together) were 153 central venous ports and 73 Hickman catheters. This indicates that catheter malfunction appeared in 11% of the central venous ports and in 27% of the Hickman catheters.
We found a significant relationship between catheter malfunction/thrombosis and catheter type. ($X^2(1, N = 226)9.57, p = 0.002$). Hickman catheters were more likely to be malfunctioning than were central venous ports.

Catheter outcome: Most catheters were removed because the catheter was no longer was needed. In figure 13 cause of catheter outcomes are visualised in a pie chart. Others represent two cases of accidental removal of catheter, in three patients the catheter had to be removed due to treatment (radiation and surgery) and one patient requested catheter removal.

4 Discussion

4.1 Interpretation and summation of key findings

The main objective of this study was to obtain precise data on central venous ports and Hickmann catheters that were inserted by the catheter unit at UNN HF during 2017-2019,

In total 226 catheters were inserted, of which 17 were inserted in children. Procedures were performed by eight anaesthesiologists. Demographics of the adult patient population was comparable to a previously published Norwegian study on long-term CVCs (4). Cancer was the main diagnosis in adults, which accounted for more than 80% of the cases. Haematological malignancy was the most frequent diagnosis in children.

153 central venous ports were inserted and thus the most frequently used catheter type. Main vascular access site was the right internal jugular vein. However, insertion site varied between operators. Procedural time was operator dependent, but longer for insertion of central venous ports compared to insertion of Hickman catheters (median 45 min vs. 30 min, respectively).

Pneumothorax was diagnosed in five patients (2.2%) and a chest tube was inserted in three of these patients. Hematoma was diagnosed in four patients (1.7%). This numbers are slightly higher compared with data reported by Lenz et al. (1.1% and 0.8% , respectively) (4).

One serious procedure-related complication occurred during the study period. This was a 6-year-old child (21 kg) where an artery was punctured causing a large haemothorax. The patient was intubated and received a chest tube. He was discharged from the intensive care the next day and made a full recovery.

Short-term complications occurred in 13% of the cases and long-term complications in 23% of the cases. In children, short-term and long-term complications occurred in 24% and 32%, respectively. In both adults and in children, infection and malfunctioning of the catheters were the most frequent complications. Hickman catheters were more likely to be malfunctioning compared to central venous ports (p= 0.002). We also found significant lower incidence of infection in patients who received a port to infection rates in patients who had a Hickman catheter inserted (p=0.01), indicating that there was a higher likelihood for infection in patients receiving Hickmann catheters compared to ports.

In a comparable single centre study on complications rates in patients diagnosed with solid tumours, Ng et. al. found that complication rates were five times higher in patients with Hickman compared to patients with central venous ports inserted. Infection was accounting for most of the cases, occurring in 0.86/1000 catheters days in patients with ports and 2.54/1000 catheter days in patients with Hickman catheters(13). These data are also in line with former data (14). In our study cohort we found fewer cases of infection (0.27/1000 and 0.94/1000 catheters days, respectively). However, the proportion of infection rates in central venous ports compared to Hickman catheters were similar to the incidence reported by Ng et al.

Patients who kept their catheter despite a suspicion of catheter-related infection, was all successfully treated and relapse of infection after antibiotic treatment was not recorded in any of the six cases. In addition, many of the patients that got their catheter removed, did not have biochemical findings that supported the decision. Although this only applies to a few patients, it raises the question on whether clinicians may have a too low threshold for catheter removal.

In a study on management of catheter-related bacteraemia by Fätkenheuer et al, they highlight different factors that should be taken into consideration when deciding on whether catheter removal is necessary, including patent circumstances, catheter type and type of pathogen. Several studies have shown favourable results in catheter salvage in blood-stream infection caused by coagulase-negative staphylococci(10). Such practice is also supported by the American guidelines on management of catheter-related bacteraemia, which recommend that catheter can be retrained on the basis of good clinical judgement, along with systemic and antibiotic lock therapy(11).

However, the importance of distinguishing between colonization of the catheter and infection of the host, is emphasized in several studies. Fätkenheuer et al underline that the same pathogen should be found on the catheter surface and in blood cultures in order to define CRABSI (10). In our study, infection was classified as either removal of catheter, or use of antibiotics due to a suspicion of catheter-related infection. We were not able to identify blood culture results in all patients with infection, meaning there is a high likelihood that a share of the catheters that were removed due to catheter-related blood stream infection (CRABSI), was not in fact the origin of infection.

In our study malfunctioning of the catheters was the most frequently diagnosed complication. Thrombosis was confirmed by imaging techniques in four cases. However, it is not unlikely that some of the occluded catheters were thrombosed, but this was not verified in any patient. To treat malfunctioning catheters, it is necessary to make the right diagnosis and particularly identify whether obstruction is mechanical, due to thrombotic material, or drug-related (i.e. TPN). Early treatment can reduce risk of subsequent complications such as post-thrombotic syndrome, pulmonary embolism, and infections (15)

Complications are more frequently related to Hickman catheters, but several other factors must also be considered when catheter units are evaluating current practice. Relevant factors are availability of devices, risk of adverse events, patient needs, patient preferences, operating theatre capacity, and costs. Anyway, the main objective and focus should always be to maximize patient satisfaction and avoid harm (16).

In a Swedish study on clinical implications of CVCs, use of peripherally inserted central catheters (PICCs) was investigated. At many hospitals, including UNN Tromsø, the catheters are inserted by trained nursing staff. The study suggests that this is one of the reasons why this procedure is gaining increased popularity is because it may ease the pressure on theatre capacity. However, very little high-quality evidence supports the increasing use of PICCs. In fact, compared to ports the study found that PICCs were associated with more catheter related deep vein thrombosis (DVT) and adverse events, and subsequently higher costs(16)

4.2 Limitations

Some limitations should be taken into consideration when interpreting the current data. First, the quality of retrospective data relies entirely on accurate and thorough documentation by the performing clinicians. Second, missing data in the hospital record system may impact on some variables and we might also have failed to notice data during the collection process.

Third, operators used different wording and spellings in their reports. This made search engines less useful when applied to the electronic hospital record system.

Fourth, a total of 226 procedures were analysed. This is a relatively small number compared to previously published data from other centres. This must be taken into consideration when interpreting the results. Anyway, data may be useful for other low volume catheter units as a comparator in assessment of own data material.

Fifth, 10% of all catheters placed at the catheter unit during the study period 2017-2019 were followed up at Nordlandssykehuset. Unfortunately, due to an intricated and time consuming application process to the data protection officer at Nordlandssykehuset, we decided not to include patients who were followed up at this hospital.

Last, variable definitions vary in the existing literature. In this study, malfunction and infection has a broad definition. It is important to look at the elucidations and take this into account when reading the results, especially when compared to other published data.

4.3 Future perspectives

To conduct regular monitoring and improvement of health care services is enshrined by the Norwegian law(17). To continue to improve the quality of care in patients receiving CVCs, ongoing evaluation and research is necessary. The demands for long-term CVCs are likely to grow in the upcoming years as the life-expectancy of cancer patients continues to increase. To get hold of relevant data, it is necessary to better evaluate the need of future resources.

Whilst working on this project, we have dedicated little focus to operator training and experience. Internationally, UNN Tromsø is considered a small hospital and getting enough procedures per operator is key to gain and maintain procedural skills. This is especially relevant on children, as a total of only 17 procedures were performed during 2017-2019. Gaining more information about operator practice, especially in relation to catheter outcome and complications, would be requisite to optimize procedural quality.

Today, all long-term catheters are inserted on order by the treating physician. By working on this project, we have become aware of the benefits and disadvantages of different CVCs and the importance of choosing the right device for the right patient. The decision should be well-founded and derive from quality-based research. To explore various aspects of the decision-making process in patients receiving CVCs at UNN, would be an interesting topic to further investigate, especially in regard to patient participation.

Considering malfunction was the leading cause of removal, and therefore likely a contributor to increased costs and patient burden, it would be engaging to further investigate how malfunction better can be diagnosed, prevented and treated. In addition, it would be compelling to look more into management of infection, as we discovered that removal of several catheters, was not always supported by biochemical findings (I.e. catheter tip cultures or blood cultures). Moreover, treatment with antibiotics was successful in all cases where the catheter was retrained, despite a suspicion of catheter-related infection. This substantiates the importance of good clinical judgement and individual assessment along with the use of clinical guidelines.

Future research should focus on safety, quality, cost reductions, measures to reduce harm and aim to increase patients' satisfaction with the service provided.

5 Conclusion

Complications were more frequently diagnosed in patients who received a Hickmann catheter compared to patients who had a central venous port inserted. Malfunction/thrombosis and infection were the most frequently diagnosed complications. Biochemical findings did not always support removal in cases of catheter related infection, which indicate a low threshold for removal. Future research should aim to improve methods and reduce complications

Figures and tables

Table 1 – patient demographics by gender in children (<18 years) and in adults. Number (percent)

	Children	Adults
Male	10(59%)	59(28%)
Female	7(41%)	150(72%)
Total	17(100%)	209(100%)

Table 2 – Patient demographics by age, height, weight and body mass index (BMI) in children and adults.

	Children		Adults	
	Median(IQR)	Range	Median(IQR)	Range
Age (years)	7(5-14)	0-17	58(47-64)	19-79
Height (cm)	118(104-157)	60-172	168(162-175)	139-189
Weight (kg)	27(17-49)	6-72	69(60-80)	37-137
BMI (kg/m^2)	17(16-20)	13-24	24(22-28)	14-49

Figure 1: Illustration of central venous catheter(18) and Hickman catheter(19). Illustrations retrieved with permission from the national cancer institute.

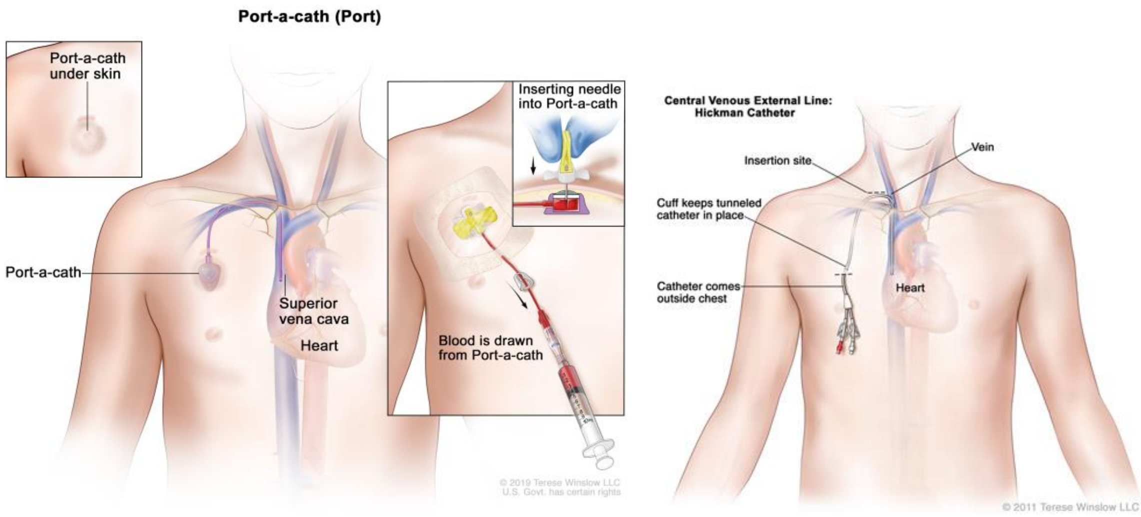

Figure 2 – Flowchart showing numbers of catheters included

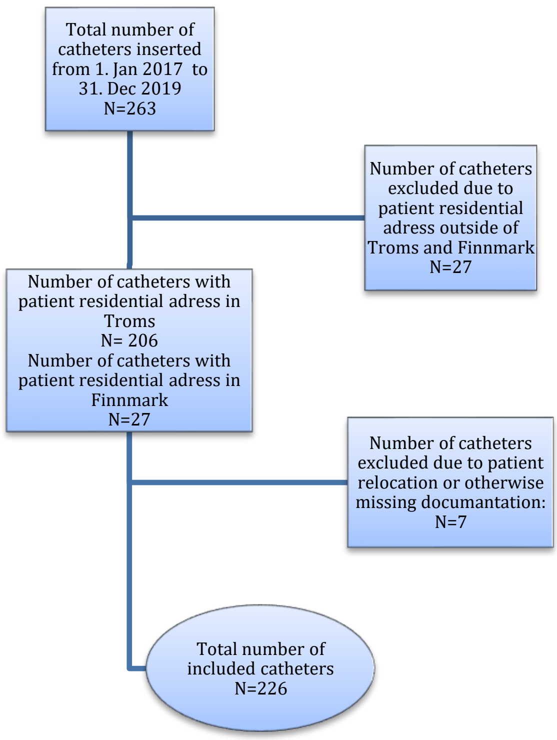

Figure 3 – bar chart showing frequency of main diagnosis in adults

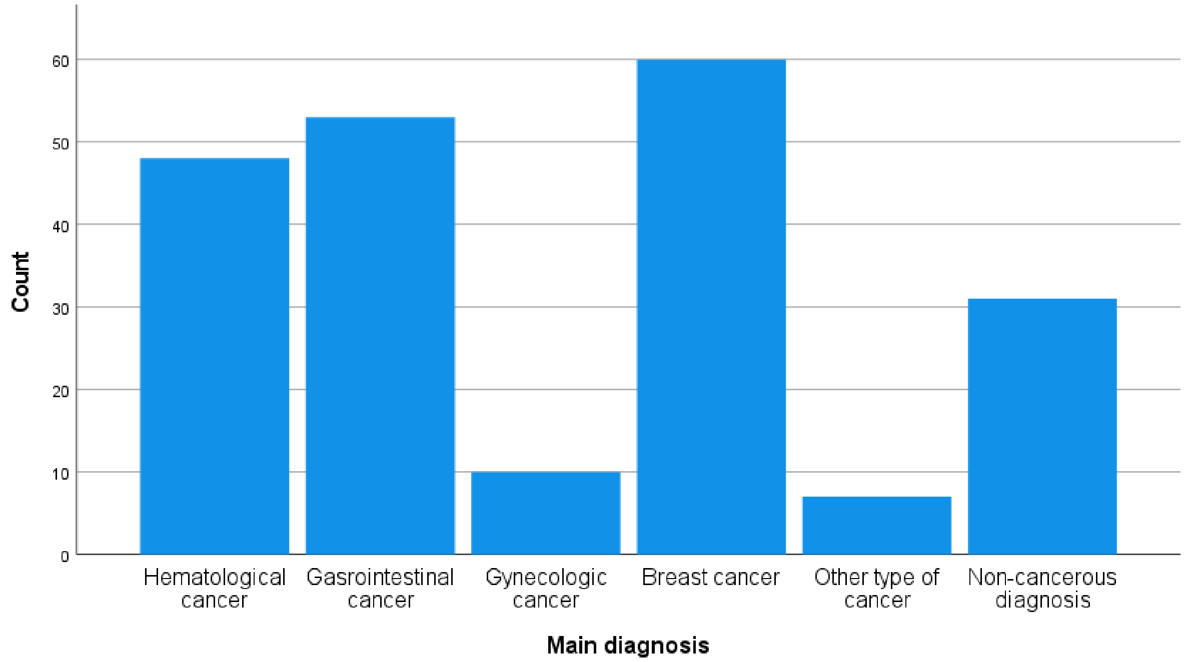

Table 3 – Main indication for catheter insertion in children and adults. Number (percent). TPN = total parenteral nutrition.

	Children	Adults
Chemotherapy	12(70%)	139(66%)
TPN	0(0%)	31(15%)
Stem-cell transplant	0(0%)	22(11%)
Difficult peripheral vein access	1(6%)	4(2%)
More than one indication	1(6%)	7(3%)
Other	3(18%)	6(3%)
Total	17(100%)	209(100%)

Figure 4 – Histogram showing frequency of catheter type inserted in children and adults. Hickman 3 lumen was not inserted in children.

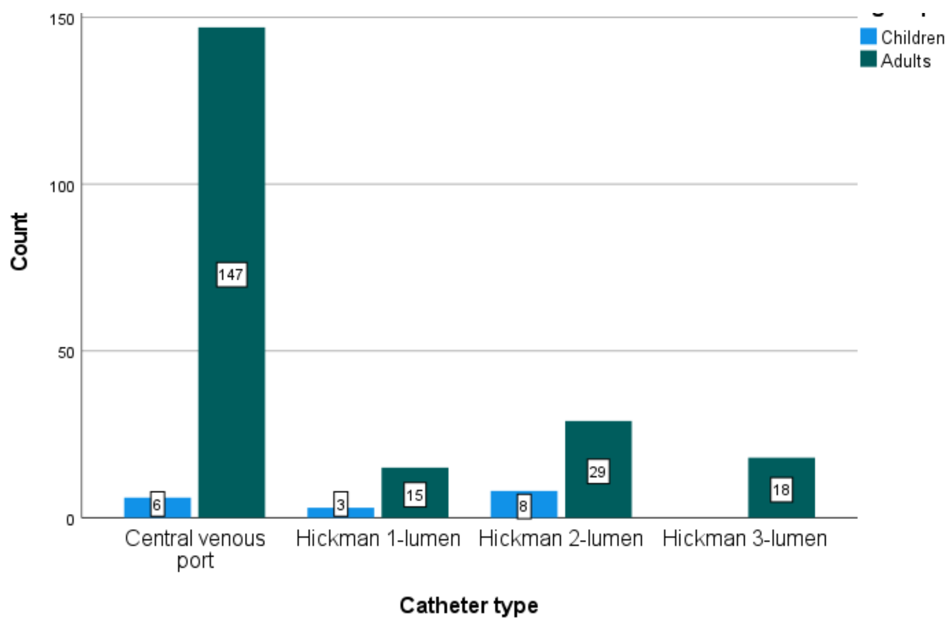

Figure 5 – Histogram showing insertion site in children and adults. The subclavian vein was not accessed in children.

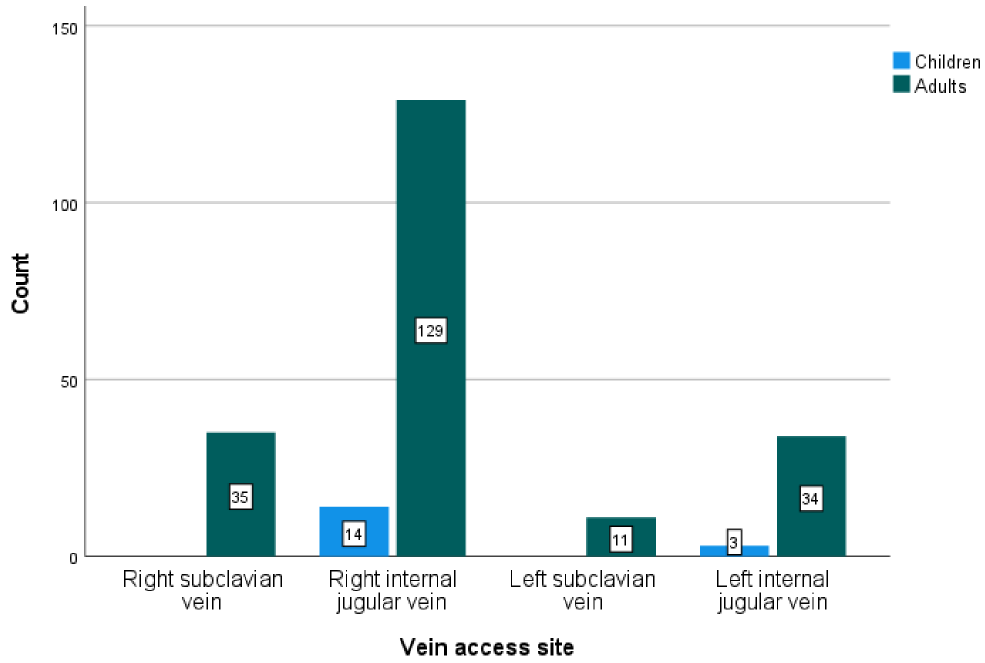

Figure 6 – Boxplot showing procedural time in children and adults. Median value, quartiles, range and outliers.

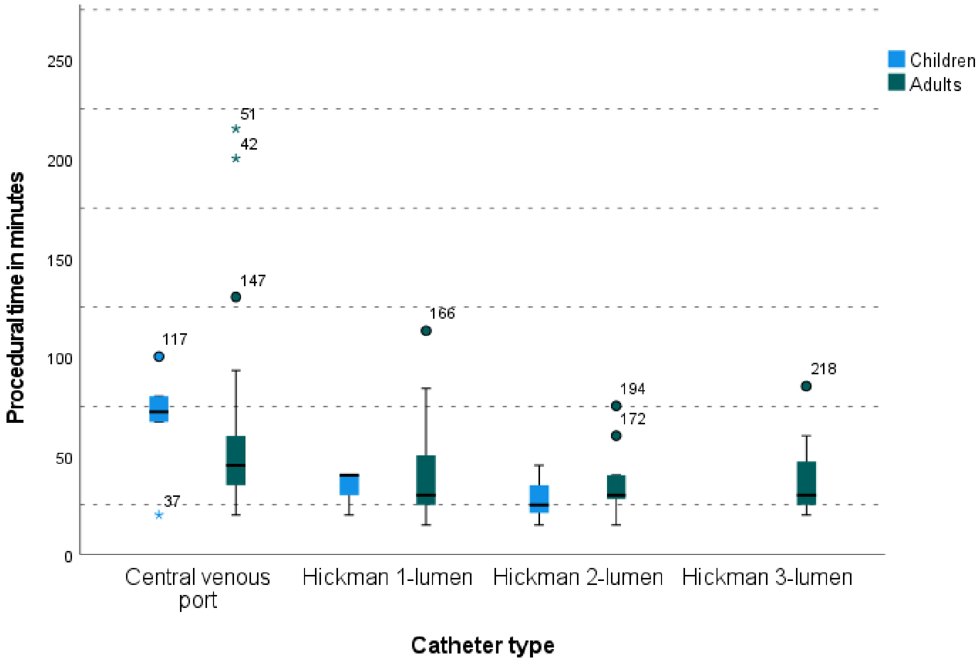

Figure 7 – Histogram showing number of catheters per operator in adults.

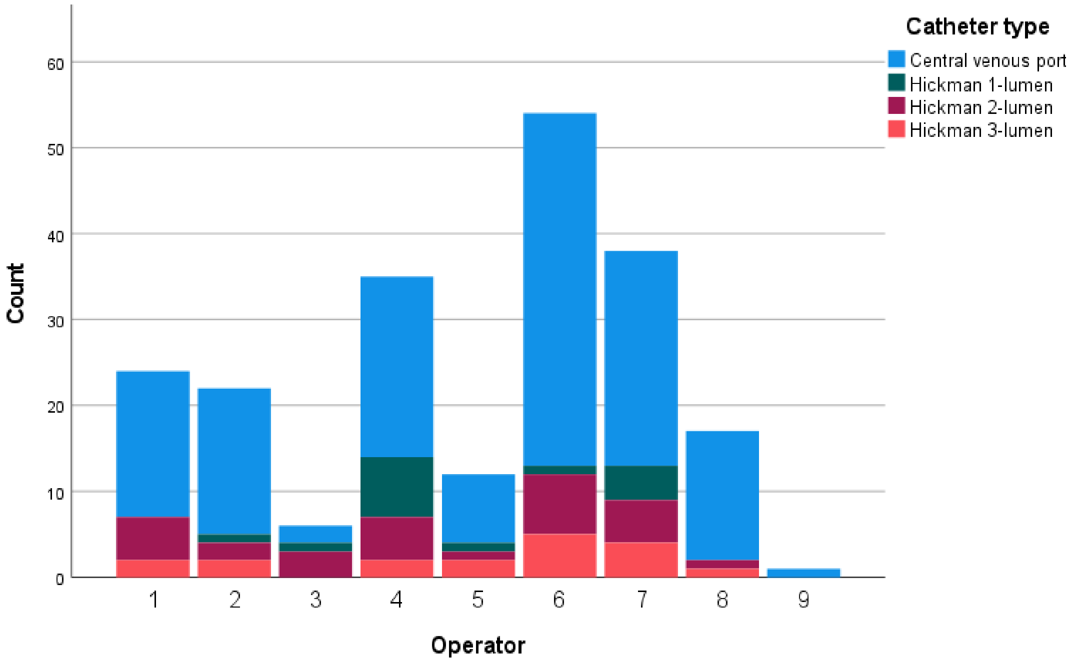

Figure 8 – Histogram showing number of catheters per operator in children.

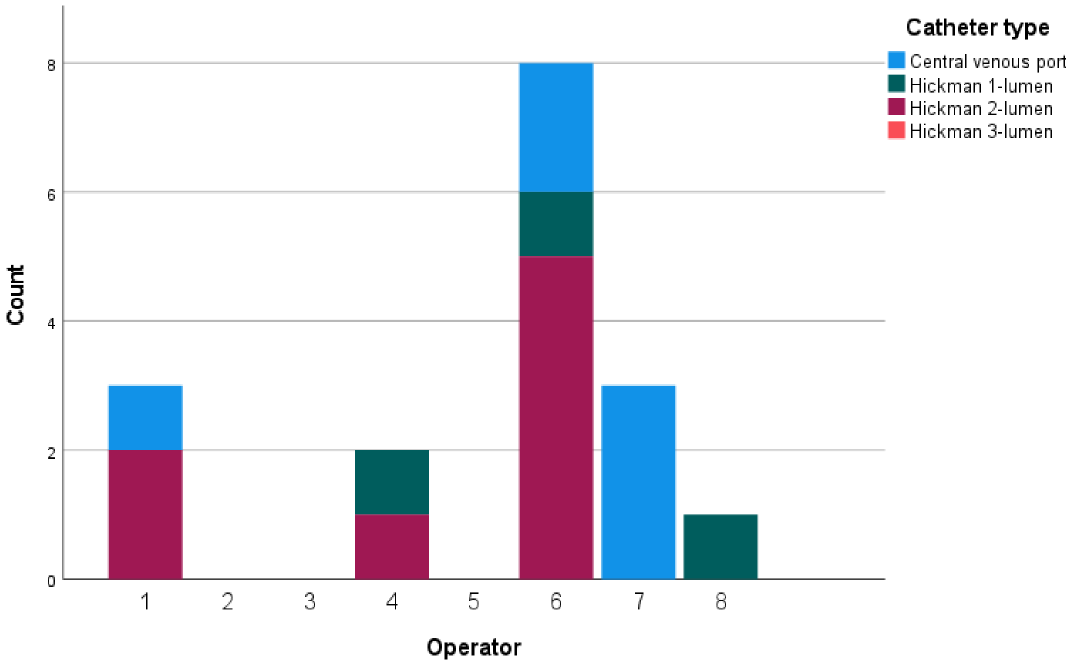

Figure 9 – Boxplot showing number of catheter days per catheter type in children and adults. Median value, quartiles, range and outliers are visualised.

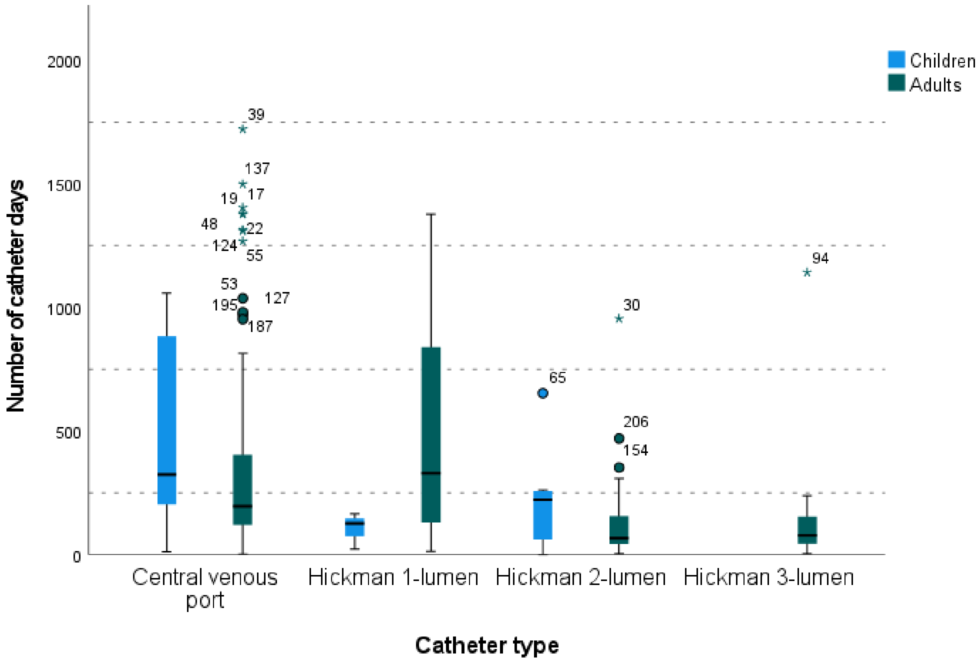

Table 4 – Distribution of short-term complications (diagnosed within 30 days) in children and adults. Number(percent).

	Adults	Children
Malfunction	2(1%)	0(0%)
Thrombosis	2(1%)	0(0%)
Infection	9(4%)	2(12%)
Pneumothorax	5(2%)	0(0%)
Hematoma	4(2%)	0(0%)
Others	6(3%)	2(12%)
No complication	181(87%)	13(76%)
Total - missing	209 - 0	17 -0

Table 5 – distribution of long-term complications (appearing beyond 30 days) in children and adults. Number (percent).

	Adults	Children
Malfunction	24(12%)	4(26%)
Thrombosis	5(2%)	0(0%)
Infection	17(8%)	1(6%)
Other	1(1%)	0(0%)
No complication	142(68%)	9(53%)
Total - missing	189 – 20	14 - 3

Figure 10 – Flowchart showing incidence and management of local and systemic infection in children and adults with central venous ports inserted. Number represents frequency.

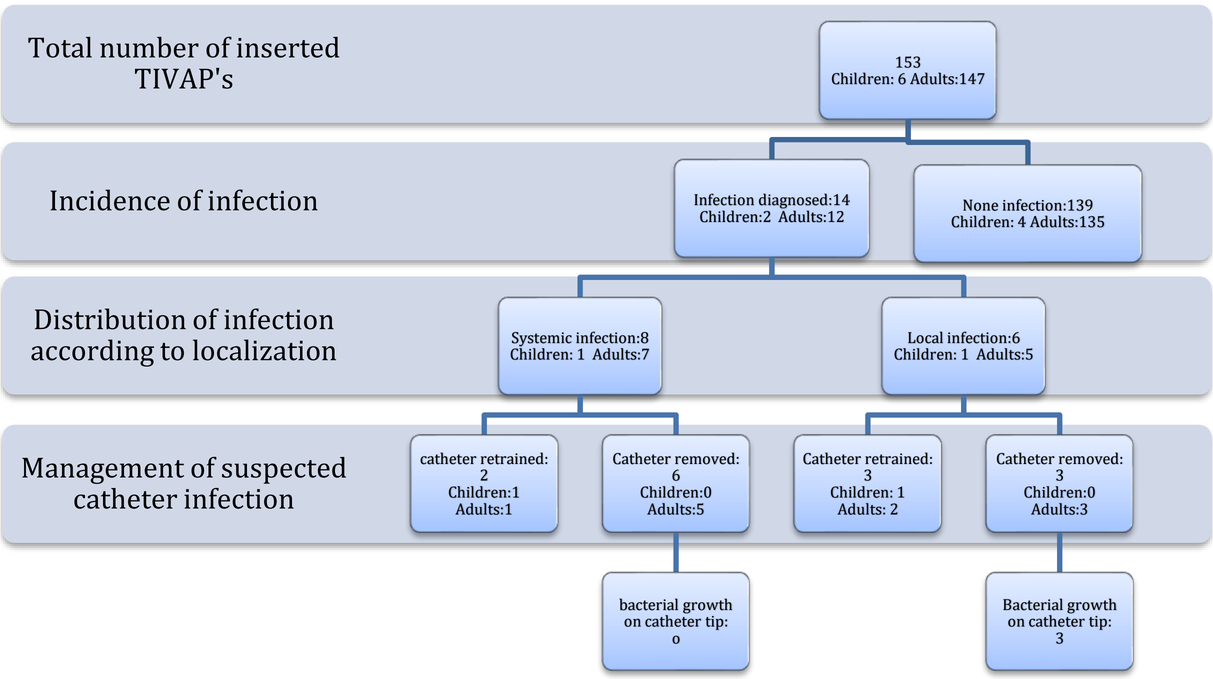

Figure 11- Flowchart showing incidence and management of local and systemic infection after Hickman catheter insertion. Number represents frequency.

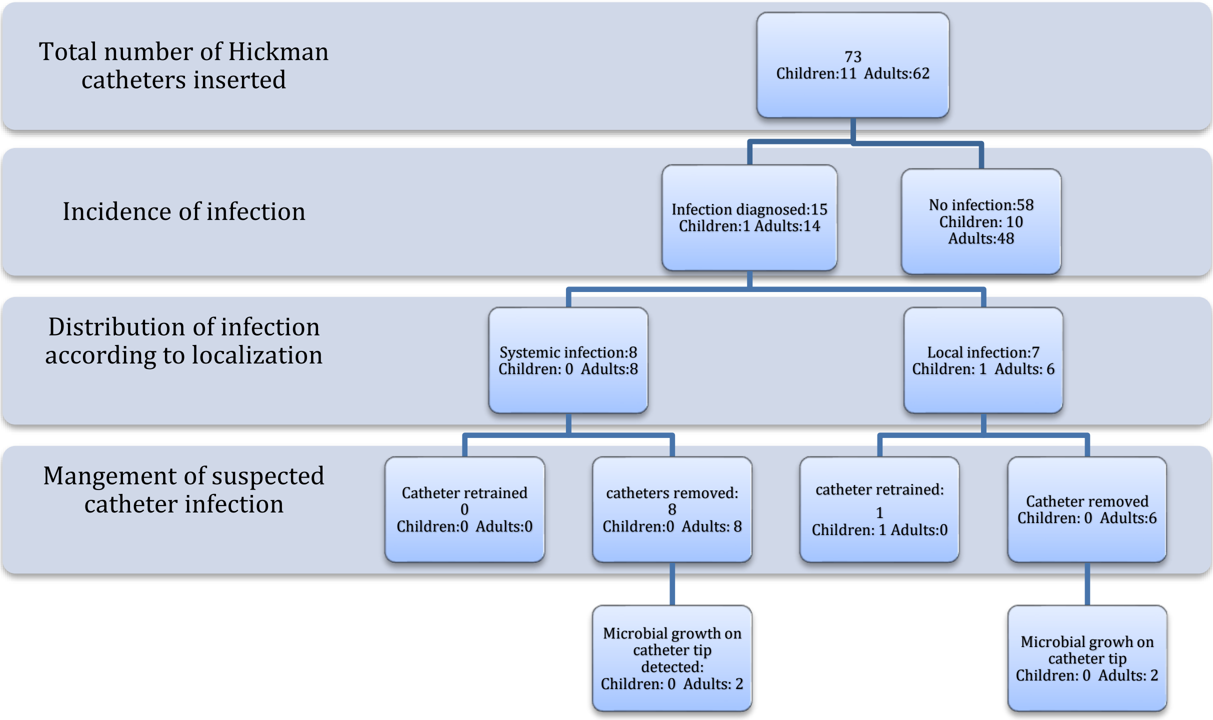

Table 6 – Crosstabulation showing relationship between infection rate and pharmacological immunosuppression/use of prophylactic antibiotics during procedure. Number (percent of infection cases).

	Pharmacological immunosuppression N=146	Prophylactic antibiotics N=21
Short-term infection (N=11)	5(45%)	1(9%)
Long-term infection (N=18)	6(33%)	3(17%)

Table 7 – Crosstabulation showing distribution of total infection rate in central venous ports and Hickman catheters

	Central venous port N=153	Hickman catheter N=73	Total N=226
Yes (N=11)	14(9%)	15(21%)	29(13%)
No (N=18)	139(91%)	58(79%)	197(87%)

Figure 12 – showing incidence and management of malfunction and thrombosis in central venous ports and Hickman catheters inserted in children and adults.

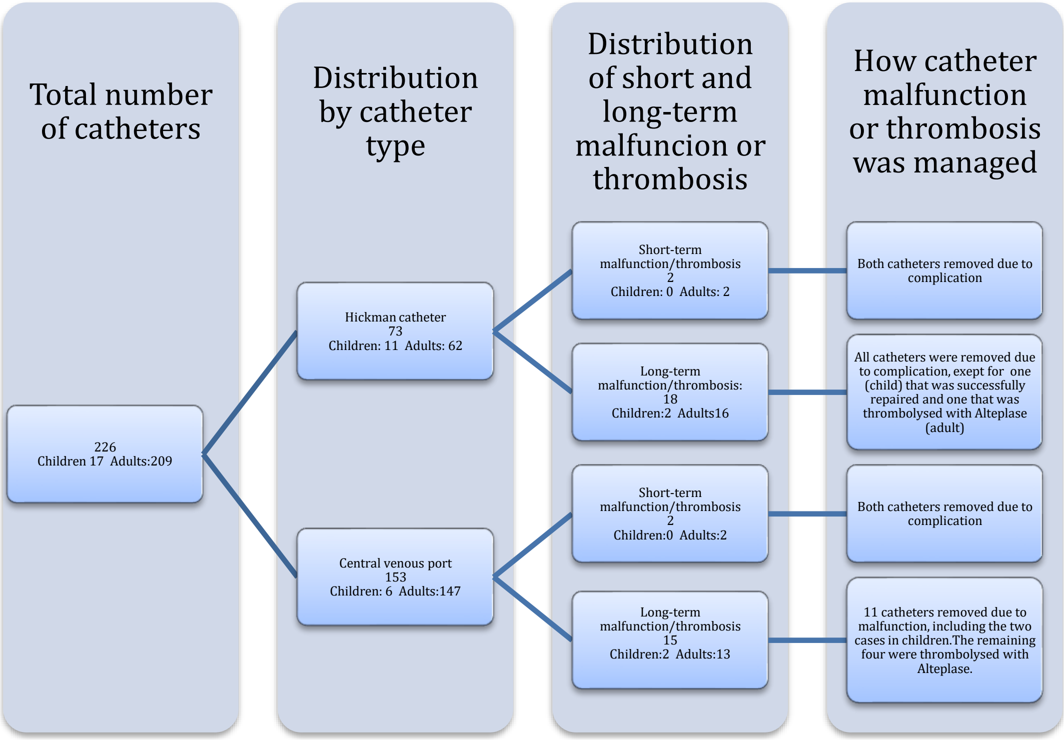

Figure 13 – Pie chart showing cause of catheter outcome.

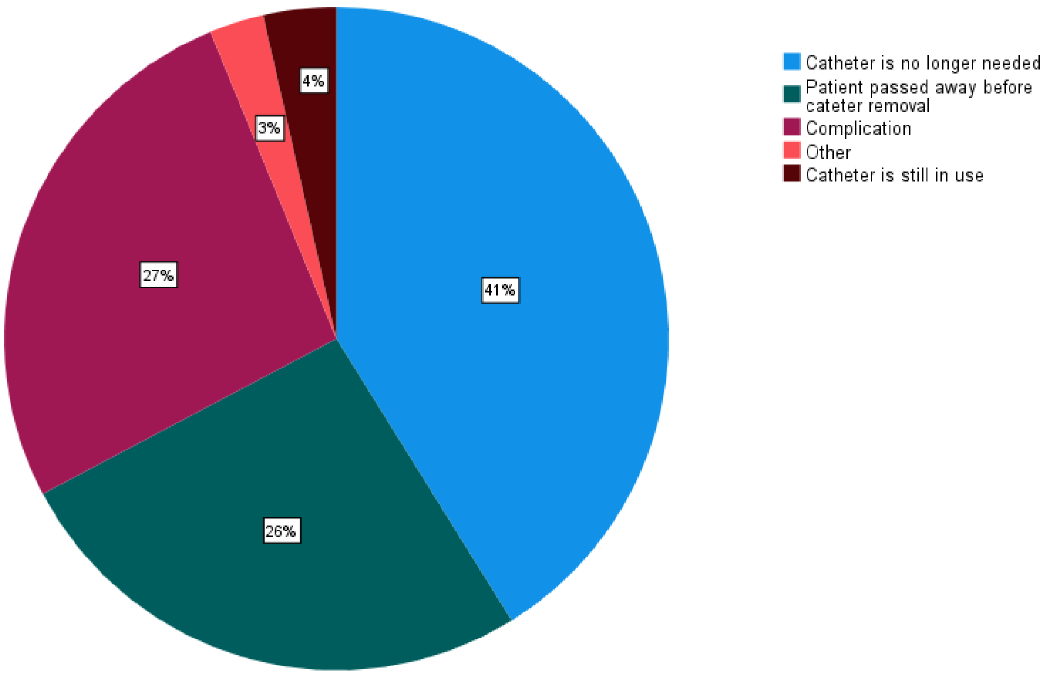

Table 8- Distribution of malfunction and thrombosis by catheter type in in children and adults. Number represents frequency.

Total (N=226)	Children (N=17)		Adults (N=209)		Total
	Short-term	Long-term	Short-term	Long-term	Short- and long-term
Central venous port	0	2	2	13	17
Hickman 1-lumen	0	1	0	4	5
Hickman 2-lumen	0	1	2	6	9
Hickman 3-lumen	0	0	0	6	6
Hickman - total	0	2	2	16	20

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