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Atypical use of PICC as centrally inserted central catheter in infants and neonates: Report of a 10-year experience

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Abstract

Purpose: The aim was to determine the success, safety and post procedure complications of peripherally inserted central catheters as centrally inserted central catheters (CICC).

Materials and method: One hundred and sixty-one consecutive infants and neonates, who underwent image guided tunnelled central venous catheter insertion were retrospectively evaluated between April 2008 and April 2018. Patient's demographics, site of access and procedure details were recorded. Outcomes included technical success and post procedure complications.

Results: One hundred and eighty-two CICCs were inserted in 161 patients (49.7%, $n = 80$ male). Mean patient age was 100 days (range: 0–342) with a mean weight of 4.20 kg (range 1.80–9.40). The most common indication was for antibiotics administration (41%; $n = 66$). Technical success was 99% (181/182). Early complications (<7 days) were seen in 8.8% ($n = 13$). This included inadvertent line removal in 5.5%, catheter-related bloodstream infection in 1.1% and catheter occlusion in 2.2% ($n = 4$). Average line functional duration prior to removal was 26 days (range 0–180). 77.5% of the lines lasted for the intended duration of treatment. In the neonate subgroup, 84.1% (37/44 lines) of lines remained in situ for the intended duration of treatment.

Conclusion: Tunnelled central venous catheters using non-cuffed peripherally inserted central catheters in infants is a safe technique with excellent success rate and minimal complications rates.

Keywords

Peripherally inserted central catheter line, central inserted central catheter, infant, radiology, interventional radiology

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Introduction

An integral part of managing paediatric patients with complex cardiovascular, gastrointestinal and oncological medical conditions is the continuous access of a central vein.[1] Indications include the need for total parenteral nutrition (TPN), long term antibiotics, blood products, chemotherapeutic agents and frequent blood sampling.[1] Insertion and maintenance of central venous access however, is a greater challenge amongst the paediatric population compared to adults due to their behaviour, smaller vessel dimensions and anatomy.[2]

Failure of central venous access leads to missed antibiotic doses and the inability to receive prescribed TPN or fluids.[3] As a result, these children often receive suboptimal medical care. Repeated central venous catheter (CVC) insertions increase the likelihood of general anaesthesia and catheter related complications, theatre time and costs to the health care system.[3] Neonates suffer the most and often

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have the highest complication and lowest success rates amongst the paediatric population owing to technical complexity and to the greater ratio of line/vessel size ratio.[2,3]

Current catheter options include epicutaneo-cava catheters (ECC), peripherally inserted central catheters (PICC), implanted ports and centrally inserted central lines (CICC).[1,4] Tunnelled-cuffed catheters, either in silicone or in polyurethane, are characterized by their Dacron cuff which acts as an anchor in forming adhesions within the subcutaneous tissue, reducing the risk of inadvertent line removal and related infection.[1,4] Their insertion and removal however, require a skilled operator and patients have to be brought back into theatre for dissection of the adhesions. As a result, they may require general anaesthesia.[1,4] Their use in infants and neonates are also limited due to patient size.[2]

Non-cuffed PICCs and epicutaneo-cava catheters (ECC) in comparison have narrower lumens and lack the internal cuff therefore can be inserted and removed in a ward environment without the need for general anaesthesia or a skilled operator.[1,4] This however, also makes them prone to inadvertent line removal due to their lack of internal fixation and their site of entry being in the periphery, making them more likely to get caught for example as parents pick up their children and whilst changing clothes.[1,2,4] To combat some of these technical issues, we propose a simple method of using adult PICC lines as a CICCs in infants and neonates.

We present our 10-year, single centre experience with off label use of new generation polyurethane PICC as CICC in children under 1 year of age. Our primary aim was to evaluate its success rate, complications and durability of the lines and if they remained in situ for the total intended duration along with the safety of this technique.

Methods

Study design

This was a retrospective single centre cohort study and therefore it was exempted from Institutional review board. Images and procedural reports from all eligible cases were retrieved from the electronic radiology archiving and Information Systems between April 2008 and 2018. Patient's demographics were retrieved from the electronic patient records system.

Patient selection

Data collected from consecutive patients under 1 year old who had a CICC placed. Decision to use this technique was made by the operating interventional radiologist considering the duration and type of treatment, suitable veins during intra-operative mapping and patient size. Central venous access was performed after either failed peripheral access or if the child's vein size was considered unsuitable for peripheral access.

Data recorded included patient demographics, procedure details including date of insertion, date of removal, reason for removal, indication, catheter duration, PICC device type, site of access and use of imaging (ultrasound, fluoroscopy or both). Patients were excluded if they were older than 1 year and those with insufficient clinical data.

Study outcomes and definitions

Outcomes included technical, clinical success and post procedure complications. Technical success was defined as inserted correctly CICC confirmed on imaging and functioning 24 h after insertion. Clinical success was defined as those remaining in situ for the intended duration of treatment. Complications were defined as early, if they occurred within the first week, or late if occurring thereafter, up until line removal. Reason for removal included elective (planned) or as a result of a complication. Exclusion criteria included paediatric patients >1 year old and those with insufficient follow-up data where the reason of removal or catheter days could not be determined.

Procedure technique

Procedures were carried out in the interventional suite under general anaesthesia and use of local anaesthetic at the operative site. Routine haematological tests ensured that there were no coagulation abnormalities (platelet count and INR). The internal jugular vein was often the preferred access site due to operator experience. Real time ultrasound was employed to localize a suitable and patent vein with a GE L8-18i-D Hockey Stick Probe'.

In general, in infants >5 kg a 4F micro puncture set (Wm Cook, Bloomington, Indiana) was used to access the vein. This consists of a 21G needle, a 0.018 inch soft straight tip guidewire and a 4.5F, micro introducer. In children <5 kg, we often used a small variation on this equipment with the use of a shorter 4 cm 21G as opposed to the standard 7 cm needle. Either a single 4F or double lumen 4F PICC line could be placed through this sheath. In very small infants <5 kg, a 3F single lumen PICC line was sometimes used with a 3F access sheath. Placement of a 5F line was with the use of a 5.5.F peelaway sheath. The final decision with regards to the diameter of the catheter and the relative micropuncture kit however, was made after evaluation of vein diameter and accessibility using ultrasound, ensuring the catheter size did not exceed 1/3 of the internal diameter of the vein.

The PICC line tip was placed in the proximal right atrium and this was confirmed with fluoroscopy at the time of the procedure. Once the needle tip is in the IJV, blood is aspirated to confirm access has been achieved. A 0.018–inch guidewire is passed through the access needle and is manipulated ideally into the inferior vena cava.

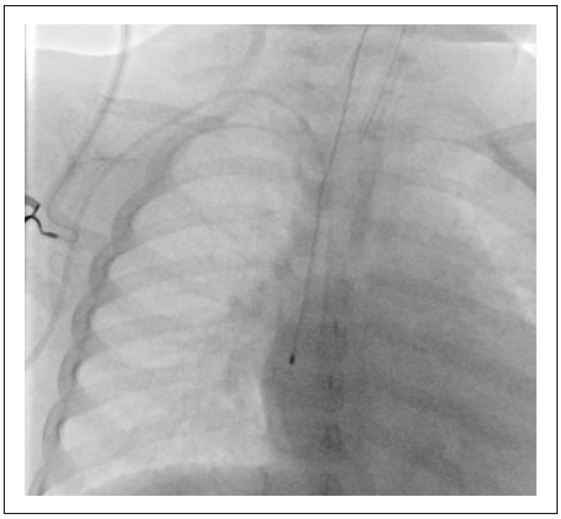

Figure 1. Right noncuffed tunnelled CVC (4F double lumen COOK PICC) placed via right IJV access.

Technique for tunnelling. CICC lines inserted via the jugular vein were routinely tunnelled under local anaesthesia, infiltrated in the subcutaneous tissue. This provides post procedural analgesia but also increased the subcutaneous space between the skin and the jugular vein to minimize risks of inadvertent incision of the cervical vessels when the skin incision is made. If local anaesthetic could not be used, a small amount of normal saline was injected to provide this space.

The line is then passed (tunnelled) subcutaneously from the anterior chest wall exit site to the incision in the jugular vein site. The chest wall exit site is situated approximately mid-way between the nipple and the axilla. A small <5 mm incision is made at both the jugular exit site and the anterior chest wall exit. Both incisions are then carefully dilated with the use of a surgical mosquito forceps.

The catheter is cut to appropriate length using fluoroscopic guidance in the same manner as conventional cuffed CICCs. Line is inserted though the peel away sheath which is subsequently removed. The final catheter position is verified with fluoroscopy, ideally located in the proximal RA (Figure 1).

The hub of the PICC is then secured with 3/O Prolene or 3/0 Vicryl suture and dressed in standard fashion with application of a Biopatch® (Johnson and Johnson). Blood is aspirated through the line with the use of a luer lock syringe filled partially with saline. This is done to ensure that the line is functioning at the time of the procedure.

Statistical analysis

Continuous variables are presented as counts and percentages, and as mean ± SD for normally distributed data and mean (range) for those without a normal distribution and compared using the independent samples *t*-test and Mann–Whitney *U* test, respectively. Categorical variables were compared using the χ^2 test. A subgroup analysis looking specifically at neonates (up to 28 days old) was also completed. Statistical analysis was done using the SPSS version 24.0; (SPSS Inc., Chicago, IL, United States).

Table 1. Summarizes the indications for PICC line insertion.

Indication	Number of patients (*n*)
Long term antibiotic therapy	66
Total parenteral nutrition (TPN)	56
Milirinone	25
Prostin	9
Frequent venesection	7
Fluids	6
Blood products[a]	6
Antiviral	4
Other[b]	8

[a]Including albumin, fresh frozen plasma, clotting factors, red blood cells.
[b]Including midazolam, phenytoin, pamidronate, amiodarone, IVIG and intralipid.

Table 2. Summarizes the site of entry of PICC line devices.

Site of entry	Number of line insertions (*n*)
Right internal jugular vein (RIJV)	137
Left internal jugular vein (LIJV)	33
Left subclavian vein	11
Right subclavian vein	1

Results

A total of 195 PICCs were inserted as CICC in 174 patients over the 10-year period. Thirteen patients were excluded due to insufficient follow-up data. One hundred and eighty-two CICCs procedures in 161 patients were subsequently analysed. They included 49.7% ($n = 80$) male babies and 50.3% ($n = 81$) female babies. Mean patient age at the time of placement was 100 days (range: 0–342) with a mean weight of 4.2 kg (range 1.80–9.40). The most common indication recorded for insertion was for long term antibiotic therapy (41%; $n = 66$) followed by TPN 34.7% ($n = 56$). Indications of the remaining cases are summarized in Table 1. Of the 182 lines, the commonest line inserted was 4 Fr single lumen (54.4%; $n = 99$) followed by 3 Fr single lumen (29.1%; $n = 53$) and 4 Fr double lumen (14.8%; $n = 27$). Five French single lumen was recorded in one case (0.5%) and the 5Fr double lumen was recorded in two cases (1%).

Procedural success was 99.4%, $n = 160/161$. The right internal jugular vein was the most common site of access in 75.3% (n = 137). Table 2 summarizes the site of entry in all cases.

In total 16 lines were removed in 13 patients due to early complications. 2.1 inadvertent line removals per 1000 catheter days ($n = 8$), 0.9 catheter occlusions per 1000 catheter days ($n = 4$) and 0.4 catheter-related bloodstream infection per 1000 catheter days ($n = 2$). Late post procedure complications occurred in 21 patients including

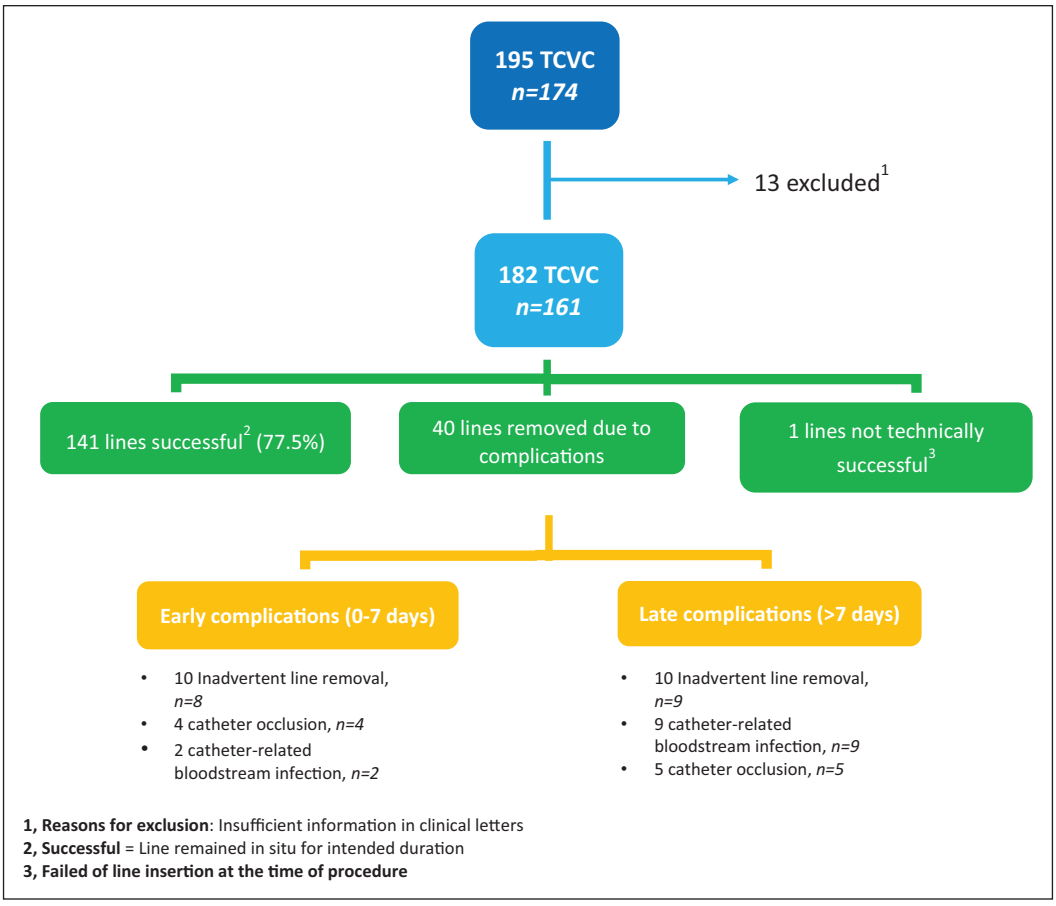

Figure 2. Summarizes the procedural data and outcomes.

2.1 inadvertent line removal per 1000 catheter days (n = 9), 1.9 catheter-related bloodstream infection per 1000 catheter days (n = 9) and 1.1 catheter occlusion per 1000 catheter days (n = 5).

The average duration which the line remained fully functional before removal was 26 catheter days (range 0–180). The clinical success as previously defined was 77.5% (n = 141/182). Figure 2 summarizes the procedural data and outcomes.

In the neonatal subgroup analysis, 44 line insertion procedures were carried out in 43 neonates they included 37.2% (n = 16) males and 62.7% (n = 27) females. Mean age at the time of placement was 16.7 days (range 0–28 days) with an average weight of 2.4 kg (range 1.8–4.5).

Early post procedure complications occurred in three patients which included 2.0 inadvertent line removal per 1000 catheter days (n = 2) and 1.0 catheter-related bloodstream infection per 1000 catheter days (n = 1). Late post procedure complications occurred in four patients which included 2.0 catheter-related bloodstream infection per 1000 catheter days (n = 2) and 2.0 catheter occlusion per 1000 catheter days (n = 2). Technical success was 100%.

The clinical success in this subgroup was 84.1% (n = 37/44) with seven removed due to complications. Figure 3 summarizes the procedural data and outcomes.

Independent T test was performed given the parametric nature of the age and weight variables. This demonstrated that there is no increased risk of complications versus Age (Mean age in complications group was 119.5 ± 104.4 days and mean age in the non-complication group was 97.4 ± 89.5 days (p = 0.18). There was no correlation between risk of complications and weight (Mean weight in the complication group was 19 ± 1.4 kg and the mean weight in the non-complication group was 4.3 ± 1.7 kg) (p = 0.58). Furthermore, there was no increased risk of inadvertent line removal with age (Mean age in inadvertent line removal group was 133.7 ± 107 days and mean age of those who didn't have inadvertent line removal group was 99 ± 90.8, p = 0.11. In addition, there was no increased risk of inadvertent line removal with weight (Mean age in the inadvertent line removal group was 4.4 ± 1.4 kg and mean weight of those who didn't have inadvertent line removal group was 4.2 ± 1.7 kg with p = 0.81).

Discussion

Demand for venous access in the paediatric population is increasing and whilst there are several options, one in four have been shown to fail before completion of therapy.[3] As a result, these patients have interrupted medical treatment. Also, additional attempts of securing vascular access are costly.[2,3]

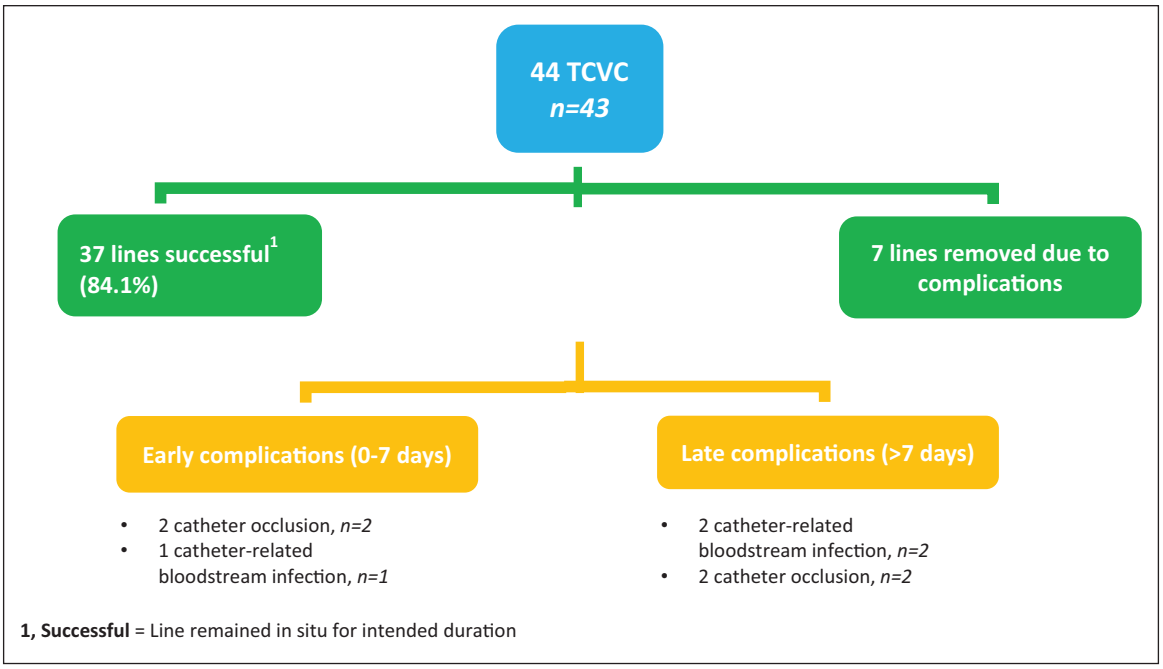

Figure 3. Summarizes the procedural data and outcomes in the neonate subgroup.

Our results demonstrate that the use of PICC as CICC is a safe technique with low complication rates whilst also having a good clinical success rate of 77.5%. Although this is in keeping with the literature[3] our study population included infants and neonates, a group who have higher complication and lower success rates in comparison to the general paediatric population.[2,3]

The inadequately low success rate of central venous catheters is owed to the high risk of complications. An estimated 40%–46% of all CVCs develop complications.[5] These include inadvertent line removal, catheter associated infection, catheter occlusion and mechanical failure, for example, breakage/kinking of the catheter.[4,6,7]

Ullman et al.[3] in their systematic review reported a pooled portion of catheter occlusion of 8.2% for PICCs, compared to 12.1% for tunnelled catheters. Blotte et al.[8] found an occlusion rate of 5.5 per 1000 catheter days following placement of silicone tunnelled-cuffed catheters, compared to 7.0 after PICC. Additional studies have also shown PICCs are associated with lower frequency of catheter occlusions[2,9] most likely due to their preferential use in short-term management.[2] We report 4.9% catheter occlusions which is comparable to the available literature.

The catheter related infection in the literature ranges between 3% and 51%.[3,10–13] Cruzeiro et al.[12] reported an infection rate of 11.6% looking in their series if 120 neck lines and 25 groin lines. Borretta et al.[13] looking at PICCs in oncology patients reported 7% line removal rate due to infection. Ullman et al.[3] in their systemic review reported 8.6% pooled rate infection rate for PICCs and 19.9% for tunnelled catheters.

Multiple studies have also been conducted to assess rates of inadvertent line removal amongst PICCs.[3,14] Jumani et al.[14] found accidental dislodgement of PICCs caused 4.6% of lines to be removed in a cohort study over a 6-year study period. Ullman et al.[3] reported a pooled proportion of 5.4% cases of inadvertent PICC removal and 7.0% for tunnelled catheters. Interestingly, despite lacking the adhesive properties of a Dacron cuff which reduce the risk of catheter related infection and inadvertent line removal, our study showed these PICCs have comparable complication rates.

We reported the incidence of catheter-related bloodstream infection and inadvertent line removal to be 6.0% and 11.0%. This suggests that these non-cuffed catheters are secure and without significantly higher dislodgement rates compared to other cuffed CICCs. Their central placement makes them more resistant to an accidental dislodgement (as they are less likely to be caught on something or pulled out by the infant).

In our neonate subgroup, we found 84.1% of lines remained in situ for the intended duration of treatment, with only three reported cases (6.8%) of catheter-related bloodstream infection and no cases of inadvertent line removal, confirming these devices are secure. Other studies evaluating the use of PICC as a CICC have produced similar results.[15–17] Bernasconi et al.[15] found a clinical success rate of 63% in their cohort of 18 patients of infants and small children. Lingegowda et al.[16] found 78.9% clinical success rate in their cohort of 19 patients, aged 4 and 72 years. Both however, reported higher inadvertent line removal rates of 20.1% and 26.3% in the latter study. Lawson and Zealley[17] found 90% of lines remained in situ for intended duration,

with only one case of inadvertent line removal (4.8%) in their cohort of children all under 10 years old. Lastly, Barone et al.[18] found all 30 (100%) of their lines inserted in preterm neonates were clinically successful.

The main advantage of these lines is that if a complication were to occur, the line can be simply removed on the ward or community by nursing staff through light traction and patients do not have to be brought back into hospital, avoiding the need of a potential GA. Their use may be most appealing in the neonatal population where there are high failure rates reported and novel techniques have only produced modest results.[19,20]

There are several limitations in the procedural technique described. Choice of venous access site was made following ultrasound evaluation, however often this would be the IJV, due to operator preference. There is however, growing evidence supporting the use of brachiocephalic veins as the access site because of its larger cross-sectional diameter, patency even in hypovolaemia and superior sonographic visualization.[18,21,22] Secondly, the infusion nursing society guidelines now recommend the use of intracavitary ECG to confirm PICC line tip location rather than fluoroscopy due to the increasing evidence of its safety and accuracy.[5,23–25] Thirdly, we have historically sutured our lines in place, whereas sutureless securement devices are now the recommended practice.[26] Lastly, all procedures were performed in the interventional suite under general anaesthesia and use of local anaesthetic at the operative site, whereas work in the literature has shown that they can be performed bedside under deep sedation.[15]

Further limitations include its retrospective nature, single centre experience and relatively small number of patients. Whilst the results are encouraging, to best accurately measure durability, safety, technical success and complication rates, prospective multi-centre studies are needed comparing the use of this novel technique with standard cuffed CICC and PICCs over a significant time period.

Conclusion

Our results demonstrate that the use of PICC as CICC is a safe technique with low complication rates whilst also having a good success rate of 77.5%. Although this is in keeping with the literature[3] our study population included infants and neonates, a group who have higher complication and lower success rates in comparison to the general paediatric population.[2,3] Using PICCs as CICC is a safe and simple technique in maintaining venous access with low complication rates, particularly in neonates. It has the added advantage of a simple removal process, reducing the need of an additional general anaesthesia.

Author's note

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Declaration of conflicting interests

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Ethical approval

Exempted from Ethical approval due retrospective nature of the study.

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