HHS Public Access

Author manuscript

Am J Crit Care. Author manuscript; available in PMC 2021 April 23.

Published in final edited form as:

Am J Crit Care. 2019 May ; 28(3): 174–181. doi:10.4037/ajcc2019350.

Nursing Practice with Transthoracic Intracardiac Catheters in Children: International Benchmarking Study

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Abstract

Background: Transthoracic intracardiac catheters (TICs) are central catheters placed in the operating room at the conclusion of cardiac surgery for infants and children. Complications associated with TICs (i.e., bleeding, migration, premature removal, infection, leakage, and lack of function) have been described. However, no research was found addressing the nursing management of these catheters in the intensive care unit, including catheter dressing, securement, mobility of patients, or flushing and their impact on patient care outcomes.

Objectives: To internationally benchmark current nursing practice associated with the care infants and children with TICs.

Methods: In a cross-sectional, descriptive study of nursing practice infants and children with TICs, a convenience sample of bedside and advanced practice nurses was recruited to complete an online survey to benchmark current practice. Survey questions covered content including criteria for catheter insertion and removal, dressing care, flushing practice, securement, and mobility of patients.

Results: TICs are used by most centers providing care for infants and children after open heart surgery. A wide range of practices were found.

Conclusions: Standardizing the use and care of TICs can improve the safety and efficacy of their use in infants and children and promote safe and early postoperative mobilization of patients.

Keywords

critical care; critical care nursing; child; benchmarking; catheters

Children with congenital heart disease (CHD) represent nearly 1% of all live births worldwide[1]. Many of these children require corrective or palliative surgery at some point during their lives, and often at a young age. Perioperative and postoperative management for cardiac surgery is complex and requires central, intravenous access to provide patients with medications to support hemodynamic stability and analgesia. Central venous access is also

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This work was performed at the Children's Hospital of Philadelphia.

often obtained so that transduced catheters can provide valuable information regarding hemodynamic status of postoperative patients, including central venous and atrial pressures[2]. Transthoracic intracardiac catheters (TICs) are central catheters placed in the operating room at the conclusion of cardiac surgery. Also known as right atrial, left atrial, common atrial, pulmonary artery, and Fontan catheters, these catheters have widespread use across pediatric and cardiac intensive care units (ICUs)[3]. Many institutions prefer TICs because they spare other access points for central catheters that may be needed in the future, particularly for patients with a single functioning ventricle who will require additional surgical procedures[2,3]. The specific criteria for initial placement, method of placement, length of placement, mobilizing patients, and removal has traditionally been based on institution and surgeon preference [4,5]. Furthermore, some have questioned whether more strict and standardized criteria for their use is necessary[3].

Review of Literature

The literature on TICs in pediatric cardiac patients is sparse. Wheedon and colleagues first described the use of TICs in children in 1981 as a strategy to measure pulmonary arterial pressure during pediatric cardiac surgery[6]. During surgery, an 18-guage intravenous catheter was inserted into the main pulmonary artery through the right ventricular infundibulum. A few years later, Gold and colleagues published a study evaluating the use of TICs in children[7]. They examined 6,690 TICs placed in 5,666 patients over a 10-year period and concluded that right atrial and left atrial catheters are particularly safe. Gold and colleagues specified that 19-gauge polyurethane catheters were used for these catheters and the majority of them (approximately 40%) were placed in the right atrium. In their cohort, the overall complication rate was a mere 0.59%, including retention, bleeding, tamponade, and one death. In most cases, catheters were removed by postoperative day one or two. Intrapericardial bleeding occurring after catheter removal and cardiac tamponade was 0.22% in the left atrial and pulmonary artery catheter group; none occurred in the right atrial group.

After more than a full decade of silence in the literature regarding practice and outcomes related to TICs, Flori and colleagues published the first prospective study examining the use, complications, and morbidities associated with TICs[4]. During the one-year study period, data on 523 TICs in 351 patients were gathered. Complications associated with the catheters included lack of catheter function (10.9%), thrombus formation (0.6%), and infection (1.5%). Complications associated with TIC removal were bleeding (35%), hemodynamic instability (2.6%), and the need for intervention (11.4%). Risk factors for the need for intervention after catheter removal were age < 3 months, left atrial placement, pulmonary artery placement, and a platelet count of < 50,000/uL.

In a more recent study evaluated TIC use over an 8-year period in a single institution[5]. A total of 1404 TICs were inserted in 1118 patients and only 2.1% of catheters were reported to have complications, such as migration, premature removal, bleeding, thrombosis, and occlusion. No deaths occurred as a result of complications from the catheters. Beham and colleagues studied the risk factors for adverse events associated with TIC removal[2]. They described 4.5 French triple lumen catheters were used for right atrial TICs and 3 French single lumen catheters were used for pulmonary artery and left atrial catheters. The rate of

adverse events associated with the removal of the catheters was 19.1%, including bleeding, hemodynamic instability, tamponade, and effusions. Additionally, the rate of other TIC-associated adverse events was 4.3%, including infection, leakage or extravasation, and lack of function.

In summary, the literature available provide helpful information on the benefits and risks associated with TICs. Most of the studies reported complications associated with these catheters, including bleeding, migration, premature removal, infection, leakage, and lack of function. However, none of these research studies addressed the nursing management of TICs in the ICU, including catheter dressing, securement and flushing; mobility of patients; and their impact on patient care outcomes. These practices can influence the rate and risk of occurrence for these types of TIC-associated complications. Two care practices were briefly mentioned in the studies: heparin use and mean duration of placement. Pratap indicated that the standard to maintain catheter patency in their unit was a continuous infusion of heparin at 10 units per kg every hour for every patient until catheter removal, without a specific target for the level of anticoagulation[5]. In contrast, Beham described their policy for catheter maintenance was a continuous unfractionated heparin solution (1unit of heparin per mL of 0.9% normal saline) at a rate of 1 mL per hour through the TICs[2]. The length of time the catheters remained in place for patients also differed between studies[2,5,7].

The American Association of Critical Care Nursing (AACN) Procedure Manual for Pediatric Acute and Critical Care is the only nationally published manual that covers standardized procedures for TICs in infants and children.[8] The six procedures on TICs focus on the care and removal of left atrial, right atrial, and pulmonary arterial catheters. The procedures focus on the steps to set up transducers for hemodynamic monitoring, assessment of waveforms, and the steps for catheter removal. Many of the recommendations suggest following institution-specific guidelines on various nursing practices including dressing type and heparin concentration. No recommendations are given on patient mobility, dressing type, catheter securement, or administration of medications, infusions, and blood.

The purpose of this study was to internationally benchmark current nursing practice of infants and children with TICs. This study addressed the following questions: 1) How often are TICs used in infants and children postoperatively? 2) What are the various practices with respect to flushing, dressing, securing, and maintaining TICs? 3) Are infants and children held or mobilized out of bed with TICs in place? 4) What are the criteria and process for removing TICs?

Methods

Design

We performed a a cross-sectional, descriptive study of nursing practice associated with care of infants and children with TICs. This study was approved by the appropriate institutional review board.

Sample

We recruited a convenience sample of bedside and advanced practice nurses who care for infants and children after cardiac surgery. Prospective participants were contacted via email and in person at international conferences over a 4-month period from December 2017 through March 2018. A total of 68 intensive care nurses participated in the study, from 43 unique institutions in international locations including North and South America, Europe, Middle East and South Pacific participated in this study (Table 1). The institutions performed a wide range of pediatric cardiac surgical procedures and varied by the number of beds in the critical care unit. Nurses who were knowledgeable about the institution's current practice of TICs completed the survey and the majority had at least 6 years of nursing experience.

Measurement

We developed a 32-item online survey to benchmark current practice. Survey questions covered criteria for TIC insertion and removal, dressing care, flushing practice, securement, and mobilization of patients. The majority of questions were multiple choice, with an option (other) that allowed respondents to provide open-ended response. The survey was reviewed and approved by several experts, had face validity, and was tested internally before dissemination to participants. The survey took most participants less than 10 minutes to complete.

Analysis

For discordant answers among the nurses in institutions that had more than one nurse completing the survey, we collapsed the variable value to record any positive values for yes-no questions and highest values for count questions. Survey data were analyzed by using descriptive statistics. Chi-square and Fisher exact tests to detect statistical difference among categorical variables for comparisons of nursing practice by unit number of bed size, by institutions that mobilized patients with TICs versus those that did not, and by institutions that routinely used TICs for at least 5 days versus institutions that removed the catheters in the first few postoperative days. We used t-tests for continuous variables.

Results

The nurses who participated in the survey reported that most of the 43 institutions (n = 40, 93%). used TICs. Of the three institutions that did not use TICs, two were located in the United States, and one was internationally located. Nurses from these three institutions reported that postoperative cardiac patients had peripherally or centrally placed catheters for intravenous access instead of TICs. Institutional indications for the placement of a TIC were the complicated nature of the surgery (n = 36, 84%), the surgeon's preference (n = 31, 72%), or other reasons (n = 6, 14%), including requests from the intensive care team, monitoring reasons, access needs, or a policy that all postoperative cardiac patients have placement of a TIC.

Nurses caring for infants and children with TICs reported a wide range of practices (Tables 2 and 3). (As explained in the Analysis section, data reported by the nurses were collapsed so

that only one entry was used for each institution. Thus, percentages reported in the rest of the Results are based on a total of 40 institutions that used TICs). At approximately two-thirds of the institutions (68%) TICs were used to obtain blood samples for laboratory tests. The majority of the institutions used TICs for the administration of medications (75%−93%) and blood (65%) and for parenteral nutrition (58%). Standard concentrations of heparin were found in 84% of the reporting institutions. Furthermore, in most institutions (98%), TICs were removed in the ICU setting. Diverse health care providers were reported to remove TICs; nurse practitioners (58%) were the most common. The most frequently reported criteria for catheter removal included no longer needing a central catheter (85%), clotting or lack of function of the TIC (80%), and surgeon's preference (65%). Nurses reported that dressings are changed once every seven days in most institutions (65%), using a variety of dressing types. Institutions were relatively split on whether or not patients with TICs were mobilized out of bed; in 48%, patients are held and in 42%, patients are mobilized up to a chair. Of institutions that allowed patients to be mobilized after surgery, most (71%) did not allow mobilization in the first 24 hours following surgery.

Institutions that commonly use TICs for 0 to 4 days (n = 20) were compared with institutions that commonly use TICs for 5 or more days (n = 18). No differences were found in nursing practice with regard to the use of TICs for medication administration, flushing practice, use of fluid or heparin solutions, frequency of dressing changes, or catheter securement. Nurses working in institutions that commonly use TICs for 5 or more days were significantly more likely to report using TICs to obtain blood laboratory tests (90% vs 45%; $p = .006$) and to report the administration of blood (90% vs 50%; $p = .01$) through TICs. In addition, these institutions were significantly more likely to use a Biopatch (Ethicon) under the dressing (65% vs 21%; $p = .01$). Of note, nurses working in institutions that commonly use TICs for 5 or more days were not more likely to report higher rates of mobilizing patients out of bed.

Practice was compared between nurses according to whether or not their institution allowed patients with TICs to be mobilized out of bed. Nurses who reported mobilization at their institutions reported at significantly higher rates that their institutions cared for patients with ventricular assist devices (95% vs 63%, $p = .02$). The nurses were also more likely to report flushing TICs (95% vs 53%, $p = .003$), checking blood return (95% vs 58% $p = .007$), obtaining blood for laboratory tests (86% vs 47%, $p = .02$), and using SorbaView dressings (Centurion Medical Products) (24% vs 0% $p = .001$) than were nurses from institutions that do not mobilize patients with TICs. Finally, nurses from institutions that allow mobilization out of bed for patients with TICs reported more frequently that TICs were also removed in the step-down unit in addition to the ICU (38% vs 5%, $p = .02$).

Although we hypothesized that nursing practice might differ according to the size of the ICUs (> 20 ICU beds versus < 20 beds), we found no significant differences with respect to general nursing care.

Discussion

Our benchmarking study of international nursing practice associated with use of TICs in infants and children revealed that TICs are used by most centers that provide care for infants and children after open heart surgery. Of the nurses who reported using TICs, 95% reported that TICs are commonly used for 3 days or more. Because of the widespread use of TICs, it is imperative to develop standards, procedures, or pathways based on best practices for care since recent literature suggests that standardization limits variability and opportunities for error.[9] However, our results indicate variability in nursing practice in almost every practice identified. Using an arbitrary two-thirds majority rule, we found some themes in the current practice of nurses across institutions. For catheter flushing, aspiration, and administration practices, at least two-thirds of nurses/institutions reported that TICs are used for drawing blood for laboratory tests, heparinized solution is used as a standard fluid infusion, and that TICs are used to administer intermittent medication boluses, continuous medication infusions, and blood infusions. An interesting finding was that nurses from institutions who commonly use TICs for 5 or more days were more likely to use the TICs to obtain blood specimens, administer blood products, and use a Biopatch than were nurses from institutions that commonly use TICs for 4 days or less. These results suggest that when institutions allow TICs to remain in place longer, the catheters are being used for a wider range of practices. Although the AACN Procedure Manual for Pediatric Acute and Critical Care does not cover all of these practices, it does support checking blood return and obtaining blood samples when the catheters are being used for hemodynamic monitoring[8]. The manual also recommends using 1 to 2 units of heparin per mL of either dextrose or saline solution to maintain catheter patency. A significantly greater range of practices were also reported by nurses from institutions that mobilize patients with TICs. Nurses from these institutions may have been more comfortable caring for the patient population and managing the catheters and equipment.

Nurses reported a wide range of practices with respect to frequency of dressing change, dressing type, and special considerations for dressing if leakage is present at the TIC insertion site. The Center for Disease Control (CDC) currently recommends that central catheters be dressed with transparent dressings and changed every 7 days.[10] If leaking occurs, gauze dressings can be applied but should be changed every 2 days. Our results indicate that not all institutions are following these recommendations for TIC dressing care.

Approximately half of the nurses surveyed reported that patients are not mobilized out of bed with TICs in their institutions. Because of the growing evidence for early mobility in critical care and the positive benefits of mobilization on patient outcomes, such as reduced length of stay, nurses are well positioned to create standards of care to safely secure TICs and mobilize patients to be held, sit up in a chair, or ambulate.[11,12] This is a reasonable goal, especially because 52% of nurses in our study reported that mobilization is already happening in their institutions.

Regarding removal practices, more than two-thirds of nurses reported that TICs are removed when central access is no longer needed for the patient or if the catheter becomes clotted or non-functional. A wide variety of health care providers perform the TIC removal procedure;

nurses removed the catheters in 32% of the institutions represented. Furthermore, a majority of nurses indicated that their institution's standard was to have emergency blood available and a surgeon in house for catheter removal. The AACN Manual for Pediatric Acute and Critical Care advocates having type-specific or emergency O-negative red blood cells available on standby in the blood bank or in the unit, per institution protocol, but does not make any specific recommendations about whether a surgeon should be in house.[8] Results also indicated that TICs are most often removed in the ICU. Our findings indicate that institutions have recognized the risks for hemorrhage and potential surgical intervention after TIC removal. These risks are low, but if these complications occur, timely response and intervention are essential to treat cardiac tamponade or excessive bleeding after TIC removal.

Implications

Pediatric critical care nurses have an opportunity to create standards to minimize variation in practice, enhance safety, and improve outcomes for infants and children with TICs. Our preliminary evidence suggests that implementing standards for dressing, securement, medication administration, and mobilization would be reasonable. Our results also suggest that some institutions may need to evaluate their practice standards to ensure that nursing care of TICs are in line with other practice recommendations for central catheters such as those generally regarded as standard by the CDC. Finally, with approximately half of nurses reporting that their institutions allow infants and children to be mobilized with TICs, standards must be created to ensure patient safety during mobility and minimize prolonged immobility for patients requiring a TIC. Nurses can create improvements in care in their own institutions in collaboration with interdisciplinary team members through small tests of change or the development of new standards for the care of patients with TICs. More research is needed to determine which practices reduce the risks of dislodgement, infection, clotting, and other complications. Our results indicate that prospective research, linking nursing practice with TICs with patient care outcomes, is needed for infants and children who have cardiac surgery.

Limitations

We relied on self-reports from nurses and did not gather objective data on actual care provided to patients. Although none of the nurses were novices and this all could accurately report on the practice in their institutions, these data should be interpreted with caution because they are subjective. In addition, the results cannot link specific nursing practices with patient outcomes. Finally, the relatively small international sample limits generalizability of the results beyond the United States.

Conclusions

Despite the widespread international use of TICs, we found great variability in nursing practice associated with the indication for and maintenance of these catheters. Management of infants and children after cardiac surgery is complex, requiring adequate vascular access and close hemodynamic monitoring. Standardizing the use and care of TICs can improve the

safety and efficacy of their use in infants and children who have cardiac surgery, and promote safe and early mobilization after surgery.

Acknowledgements:

The authors would like to thank Dr. Ruth Lebet, PhD, RN, PCNS-BC, CCNS-P, for her careful review and feedback on this manuscript.

This study was supported by the Cardiac Center Research Core at Children's Hospital of Philadelphia.

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Table 1

Characteristics of institutions and participants included in the study (n= 43)

Institution/Subject Demographics	N	(%)
Location		
United States	35	(81)
Northeast	10	(23)
Southeast	5	(12)
Midwest	8	(19)
Southwest	5	(12)
West	7	(16)
International	7	16
Europe	1	(2)
Middle East	1	(2)
North America	2	(5)
South America	2	(5)
South Pacific	1	(2)
Types of Cardiac Patients Cared for at the Institution *		
Transplant	32	74
Ventricular Septal Defects	43	100
Tetralogy of Fallot	43	100
Transposition of the Great Arteries	43	100
Hypoplastic Left Heart Syndrome	43	100
Ventricular Assist Device	33	77
Number of ICU Beds		
10–14	10	23
15–19	8	19
20–24	11	26
25+	14	33
Years of Nursing Experience of Subjects		
0 to 5	3	7
6 to 10	8	19
11 to 15	10	23
16 to 20	9	21
>20	13	30

* indicates non-mutually exclusive categories

Table 2

Intracardiac Line Benchmarking Study Survey Questions

For the purpose of this survey “Line” refers to any transthoracic intracardiac catheter, intracardiac line, right atrial line, left atrial line, Fontan line, etc.

1. Please identify your role	2. Years of experience
3. Institution (will not be identified)	4. How many ICU beds in your unit
5. Please identify the types of cardiac surgery patients your unit cares for.	6. Does your institution use intracardiac lines?
7. If no, what type of intravenous access does your institution use after cardiac surgery?	8. What are the indications in your institution for the placement of line?
9. Do you draw labs off lines?	10. Do you administer any of the following through lines? IV medication boluses, continuous medication infusions, blood products, HAL, intralipids, other
11. Do you routinely flush lines?	12. Do you transduce lines as a standard?
13. What fluids do you run through lines as a standard?	14. What is the standard dressing for lines?
15. How often do you change the dressing as a standard?	16. Is your standard type of dressing different if the line is leaking at the site?
17. If the line leaks, what type of dressing do you use?	18. Do you use Biopatch under the dressing?
19. What do you use to secure line to patient?	20. Do you secure medication tubing and other tubing connected to the lines while the patient is in bed? If yes, how?
21. What measures do you use to confirm line placement?	22. Do patients get out of bed with lines?
23. What types of mobilization are permitted with lines in place in your unit?	24. How soon after placement are patients with lines mobilized?
25. How do you secure tubing connected to lines during mobilization?	26. Where are lines removed when discontinued?
27. Is it the standard to have a surgeon in house when lines are pulled?	28. Is it standard to have blood available when lines pulled?
29. Who removes lines in your center?	30. What are the criteria for removal?
31. What is the most common length of time that lines are kept in?	32. What is the longest amount of time that you are aware that lines were kept in on a patient in your unit?

Abbreviations: HAL, hyperalimentation; ICU, intensive care unit; IV, intravenous.

Table 3

General practices assessed in the survey

General Practices	N	(%)
Collecting samples for laboratory tests		
No	13	(32)
Yes	27	(68)
Administration via catheter *		
Medication bolus	30	(75)
Continuous medication infusion	37	(93)
Blood	28	(70)
Hyperalimentation	23	(58)
Intralipids	24	(60)
Other	5	(12)
Fluid Standard		
1 u heparin per 1 mL in normal saline or Dextrose	25	(62)
2 u heparin per 1 mL in normal saline or Dextrose	9	(22)
Normal saline	3	(8)
Other	3	(8)
Where are catheters removed? *		
In the intensive care unit	39	(98)
In the operating room	4	(10)
In a step-down unit	9	(22)
In a procedural area	0	(0)
Other	1	(2)
Standard for surgeon in house for catheter removal?		
No	6	(15)
Yes	34	(85)
Standard for emergency blood available for catheter removal?		
No	10	(25)
Yes	30	(75)
Who removes catheters? *		
Registered nurse	13	(32)
Nurse practitioner	23	(58)
Physician assistant	18	(45)
Intensive care physician	10	(25)
Surgeon	18	(45)
Criteria for removal: *		
Surgeon preference	26	(65)

General Practices	N	(%)
No longer require central access	34	(85)
No longer require hemodynamic monitoring of transduced intracardiac pressures	25	(62)
On full feeds	6	(15)
Catheter clotted or not functional	32	(80)
Positive culture from catheter showing growth of microorganisms	25	(62)
Leakage at the insertion site	17	(42)
Other	1	(2)
Common length of time catheter kept in place:		
1 to 2 days	2	(5)
3 to 4 days	18	(45)
5 to 6 days	6	(15)
one week or more	14	(35)

* indicates non-mutually exclusive categories

Table 4

Dressing, Securement, and Mobility Practices

Dressing, Securement, and Mobility	N	(%)
Standard dressing Type		
SorbaView (Centurion Medical Products)	5	(12)
Tegaderm (3M Medical)	20	(50)
Tegaderm with chlorhexidine gluconate (3M Medical)	7	(18)
Mepilex (Molnlycke)/silicone foam	1	(2)
Other	7	(18)
Other – open to air	2	(5)
Dressing change Frequency		
Every day	1	(3)
Every 3 days	8	(20)
Every 7 days	24	(60)
Only when soiled	4	(10)
Other	3	(8)
Different dressing if leaking from catheter insertion site?		
No	22	(55)
Yes	18	(45)
Type of different dressing when leakage at insertion site		
Gauze	14	(35)
SorbaView	3	(8)
Tegaderm	6	(15)
Duoderm (ConvaTec)	1	(2)
Tegaderm with chlorhexidine gluconate	1	(2)
Mepilex/silicone foam	2	(5)
Other	3	(8)
Biopatch (Ethicon) under dressing at insertion site?		
No	22	(55)
Yes	17	(43)
Secure catheter to patient with *		
Griplock small	4	(10)
Griplock neonate	3	(8)
Catheter guard	4	(10)
Tape	24	(60)
Other	26	(65)
Other=sutures	15	(38)
Secure medication/other tubing connected to the catheter?		
No	16	(40)

Dressing, Securement, and Mobility	N	(%)
Yes	24	(60)
Out of bed with lines?		
No	19	(48)
Yes	21	(53)
Types of mobilization with catheters *		
Up to chair	17	(42)
Ambulate	11	(28)
Held	19	(48)
How soon mobilized after surgery?		
<12 hours	1	(2)
>12–24 hours	5	(12)
>24–48 hours	8	(20)
>48 hours	7	(18)

* indicates non-mutually exclusive categories