Routine Surveillance Ultrasound for the Management of Central Venous Catheters in Neonates

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Objectives To evaluate the frequency of central venous catheter (CVC)-related thrombi detected by routine surveillance ultrasound, and to assess whether positive findings had an impact on management or outcomes.

Study design All neonates in a tertiary neonatal intensive care unit who had a CVC inserted for >14 days underwent routine surveillance ultrasound biweekly between January 2003 and December 2009. Data were reviewed retrospectively.

Results Although all neonates were asymptomatic at time of surveillance ultrasound, 645 of the total 1333 CVCs inserted in 1012 neonates underwent surveillance ultrasound, and thrombi were detected in 69 (10.7%). The CVCs with thrombi were more likely to be removed for nonelective reasons compared with CVCs without thrombi (59% vs 38%; P = .001; OR, 2.4, 95% CI 1.4-3.9). A total of 955 surveillance ultrasounds were performed to detect and monitor 69 CVCs with thrombi. The majority of thrombi were nonocclusive and nonprogressive. A change in management occurred in 8 cases of CVC-related thrombi (12%), or 1% of all screened cases. An average of 14 ultrasounds were required to detect and monitor 1 CVC with thrombus, at a cost of $951 per CVC with thrombus and $8106 per case of CVC-related thrombi with a change in treatment.

Conclusion Asymptomatic thrombi were detected in a significant proportion of CVCs by routine surveillance ultrasound. There were significant costs, but infrequent changes to patient management. *(J Pediatr 2014;164:118-22)*.

Central venous catheters (CVCs) are commonly used in neonatal intensive care units (NICUs) to provide prolonged and secure access for the administration of intravenous fluids, parenteral nutrition, and medications. CVCs can be life-saving, especially in very low birth weight and sick infants when peripheral venous access is exhausted or difficult.[1] Their use is not without risks, however; they may result in mechanical injuries, infection, or thrombosis.[2]

The use of CVCs is the most common cause of thrombosis in newborn infants, accounting for up to 89% of cases.[3] The mechanisms by which CVC-related thrombi occur can be categorized into those related to the central line, to infused material, or to patient factors. CVCs may injure the vascular endothelium and disturb blood flow, or the catheter material may be thrombogenic. Previous reports have indicated that, compared with adults and children, neonates are at greater risk for thrombosis owing to their immature hemostatic and coagulation systems, small blood vessel diameter, need for infusion of high-osmolar solutions, and low flow rate of infusate. Hemostatic imbalance associated with infection, dehydration, polycythemia, asphyxia, or congenital heart disease adds to the predisposition for CVC-related thrombi in neonates.[4-8] The majority of CVC-related thrombi are silent, but some are associated with line dysfunction, limb swelling, altered skin color or perfusion, and/or thrombocytopenia.[9]

Currently there is a knowledge gap regarding the incidence and impact of CVC-related thrombi in neonates. Published guidelines for antithrombotic therapy in children and neonates are based largely on expert opinion rather than on evidence-based data[10] and do not address the specific issue of how to screen or monitor for CVC-related thrombi. It has been the practice in the tertiary NICU of the Izaak Walton Killiam (IWK) Health Centre, Halifax, Canada, to perform routine surveillance ultrasound biweekly for any CVC remaining in situ for longer than 2 weeks.

The primary objective of the present study was to evaluate the frequency of CVC-related thrombi detected by routine surveillance ultrasound and to assess whether positive findings had an impact on management or outcome. Secondary objectives included to identify factors associated with CVC-related thrombi and to perform a cost analysis of routine surveillance ultrasound of CVCs in neonates. We hypothesized that routine surveillance ultrasound might not be necessary for the management of CVCs in NICUs.

Methods

This retrospective study was conducted by reviewing the database of all newborn infants admitted to the NICU at the IWK Health Centre between

CVC	Central venous catheter
IWK	Izaak Walton Killiam
NICU	Neonatal intensive care unit

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January 2003 and December 2009 (a convenience sample based on the time of routine ultrasound). Preterm infants composed approximately 46% of this population, with approximately 35 infants born at <28 weeks gestation admitted annually. The unit also serves as a referral center for surgical patients. In most cases, an umbilical venous catheter is kept in place for less than 2 weeks after birth before considering another CVC (if one is still needed). Standard practice involves routine surveillance ultrasound biweekly for any CVC remaining in situ for longer than 2 weeks. This includes surgical and peripherally inserted central catheters, but not umbilical venous catheters. Consent was not obtained for surveillance ultrasound studies, because this was considered part of the standard clinical care of patients with central lines. All CVCs were heparinized with 1 U heparin/mL, with a minimum infusion rate of 2.0 mL/hour. Monitoring of the lines with thrombi and potential treatment was done at the discretion of the attending physician or hematologist at the time of detection. The study was approved by the Research Ethics Board Committee of the IWK Health Centre.

The hospital's central venous access database was reviewed to collect all information related to CVCs, including indications, insertion sites, mechanical complications, duration of insertions, timing and frequency of surveillance ultrasound, and reasons for removal. Electronic health records were reviewed for other data related to ultrasound and blood work reports (eg, blood cultures). A detailed chart review was conducted for those patients with identified CVC-related thrombi to identify predisposing factors, associations, management, and outcomes. In our database, a CVC is defined as a percutanously or surgically inserted catheter with the tip located in the bracheocephalic vein, subclavian vein, inferior vena cava, superior vena cava, or right atrium. CVC-related thrombi is defined as a blood clot within the vascular system related to the presence of a CVC as identified by Doppler ultrasound.

Statistical analyses were performed using SPSS 20 (IBM, Armonk, New York). Clinical characteristics are presented as mean with SD or median with IQR as appropriate. Continuous variables were compared using the Student *t* test, Mann-Whitney *U* test, or Wilcoxon rank-sum test. Categorical variables were compared using the χ^2 test or Fisher exact test. Statistical significance was defined as $P < .05$.

Results

A total of 1333 CVCs were placed in 1030 neonates over the 7-year study period. Among these CVCs, 645 (48%) were in place for >14 days and were screened by Doppler ultrasound (Figure 1). A total of 955 surveillance ultrasound studies were performed for these 645 CVCs (an average of 136 studies per year). CVC-related thrombi were detected in 69 lines ($P = .11$; 95% CI, 0.08-0.13), with a median duration of CVC insertion at detection of 16 days (IQR, 14-28 days). A total of 156 ultrasound studies were performed to monitor these 69 lines with thrombi, with approximately 2 studies per CVC with a thrombus (Figure 2).

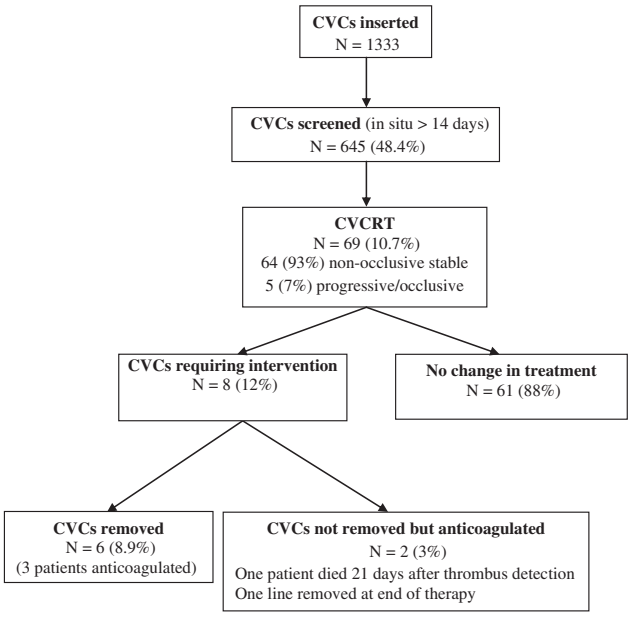

Figure 1. Outcomes after thrombus detection. *CVCRT*, CVC-related thrombi.

All neonates with a thrombus were asymptomatic at the time of detection. The incidence of CVC-related thrombi in screened infants with a birth weight <1000 g was 17.2%, compared with 9.5% in infants of higher birth weight ($P = .03$; 95% CI, 0.006-0.12). Similarly, the rate of CVC-related thrombi was 15.1% in the screened infants born at <28 weeks gestation, compared with 9.5% in infants born at >28 weeks gestation ($P = .04$; 95% CI, 0.001-0.12). There was no significant difference in the incidence of thrombosis based on postnatal age or site of catheter insertion (Table I). There was no significant difference between the 2 groups in terms of the duration of CVC insertion ($P = .65$). CVC-related bloodstream infection was detected in 15 of the 69 CVCs with a thrombus (21.7%), compared with 84 of 576 CVCs (14.6%) without a thrombus ($P = .09$; 95% CI, −0.02 to 0.19). Coagulase-negative staphylococcus was the predominant organism identified.

Of the 69 cases of CVC-related thrombis, 64 (93%) were nonprogressive and 5 (7%) were progressive and/or occlusive. In 9 cases, the hematology service was consulted, and anticoagulation therapy with low molecular weight heparin was instituted in 5 patients. There was no change in management in the majority of the CVCs with thrombi (n = 61; 88%). CVCs with thrombi were more likely to be removed for nonelective reasons compared with CVCs without thrombi (59% vs 38%; $P = .001$; OR, 2.4; 95% CI 1.42-3.9) (Table II). For those CVC-related thrombi not associated with a change in treatment, the median duration of continued CVC insertion after thrombus detection was 7 days (IQR, 2.5-15.5 days). There were no reported