Establishing Venous Thromboembolism Screening and Prophylaxis in the Pediatric Intensive Care Unit: A Collaborative, Hospital-Based Quality Improvement Project

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Introduction

Venous thromboembolism (VTE) is a frequent cause of morbidity and mortality in the adult population. While the incidence of VTE is lower in the pediatric population, complications from VTE, such as post-thrombotic syndrome, can be similar to those seen in the adult population. The incidence of VTE in children is increasing. A VTE event costs an average of $8,000 and studies estimate that VTE-associated healthcare costs in children are as high as $100,000.

Given the rise of VTE in the pediatric population along with associated costs, studies have been conducted to examine the risk factors associated with hospital-acquired pediatric VTE. Risk factors include: age 14 to 21 years, the presence of a central venous catheter, recent surgery, trauma, mechanical ventilation, malignancy, systemic infection, immobilization, increased length of hospital stay, use of birth control pills, thrombophilia, and chronic medical conditions such as obesity. The risk further increases with the presence of 3 or more of these factors.

While evidence-based guidelines for the prevention of hospital-acquired VTE in adults are well established, few such guidelines exist for the pediatric population. Authors in one review came up with the following recommendations for VTE risk reduction in the pediatric population: the use of mechanical thromboprophylaxis should be considered in older children and adolescents who are at an increased risk of VTE, mechanical thromboprophylaxis may be helpful when there is a high risk of bleeding or to complement anticoagulant-based prophylaxis when there is a particularly high risk of VTE, and children, particularly adolescents, with multiple risk factors for VTE should be considered for thromboprophylaxis with low-molecular-weight heparin. In 2011, Raffini et al. demonstrated the feasibility of incorporating a VTE risk stratification and thromboprophylaxis screening tool in a pediatric intensive care unit (PICU). The study showed marked improvement of compliance with the tool from a baseline average rate of 22% to an average rate of 82% (with intermittent improvements up to 100%) over a 4-year study period.

Prior to this project, no VTE risk stratification or thromboprophylaxis screening tool existed at Palmetto Health Children’s Hospital (PHCH). PHCH has been a member of the Children’s Hospitals’ Solutions for Patient Safety (CHSPS) since January of 2013. Funded by the Centers for Medicare and Medicaid Services, the CHSPS is a network aimed at preventing 10 hospital-acquired conditions by sharing standardized tools and techniques across 78 pediatric hospitals throughout the United States. Within the network, VTE is the third most frequent hospital-acquired condition which the CHSPS seeks to prevent. Using the definitions provided by CHSPS and the screening tool used by Raffini et al., the overall aim of this project was to create a feasible VTE screening and prophylaxis tool in PHCH’s
The specific goal of the project was to achieve 70% monthly compliance with a VTE screening tool in the PICU in the seven-month post-implementation period (October of 2013 to April of 2014).

**Methods**

Before attempting to initiate a VTE screening and prophylaxis tool, baseline incidence of hospital-acquired VTE for PHCH in 2012 was determined. Utilizing the CHSPS’s operational definition, VTE was defined as deep vein thrombosis (DVT), including clots in deep veins in the upper and lower extremities, cerebral sinuses, right atrium, and abdominal veins, and pulmonary embolism, including clots in the lungs and associated vessels. In order to be considered a hospital-acquired VTE, only those identified after the first 48 hours of admission or within 30 days of a patient’s last discharge were included. Multiple clots identified on the same day were considered a single VTE event. Exclusion criteria for VTE included: any admissions with a >24 hour period in the neonatal intensive care unit, any patient under 6 months of age, any VTE present on admission or within the first 48 hours after admission, cases in which any imaging report identified a thrombus or fibrin sheath limited to a catheter only with no vascular component, arterial thromboses, and superficial vein thromboses.

In order to establish baseline incidence of VTE at PHCH, venous Doppler and computed tomography angiogram (CTA) reports for those aged 6 months to 18 years of age in 2012 were obtained from the vascular and radiology departments. Reports were reviewed and the presence of VTE was determined using the CHSPS’s criteria. VTE incidence was reported as the number of VTE events over the total number of patient days per 1,000 patient days. Using medical record numbers, chart reviews of patients with VTE were then performed to obtain baseline patient characteristics. Venous Doppler and CTA reports were then reviewed on a monthly basis from 2013 to April of 2014 to follow VTE incidence at PHCH.

After determining baseline incidence of hospital-acquired VTE for PHCH, an initial VTE screening and prophylaxis tool was created using the Raffini et al. algorithm as a guide. The algorithm began with initial risk assessment based on an age cut-off of ≥14 years which was chosen based on prior studies. The next step of the algorithm stratified patients into VTE risk categories of low risk, at risk, and high risk based on the presence of 3 or more risk factors as previously described. The final step of the algorithm involved the incorporation of prophylaxis based on risk assessment and contraindications to thromboprophylaxis per prior guidelines.

The PICU was chosen to be the location of this pilot project because PICU patients were thought most likely to have risk factors for VTE, PICU nurses have fewer patients per nurse allowing more time to complete the screening tool, and the PICU conducts multidisciplinary rounds. Night shift nurses were responsible for obtaining the screening tool from a binder at the nurses’ station on a nightly basis for all PICU patients. The risk assessment portion of the tool was to be completed by night shift with the thought that less paperwork was filled by night shift versus day shift. The prophylaxis portion of the tool was then to be completed by day shift while rounding with the PICU team. The screening tool was then to be placed back in the binder at the nurses’ station for later review. The plan for the screening tool was discussed with PICU nurses and nurse management as well as PICU attendings prior to its initiation.
After initiation of the screening tool, monthly meetings with nursing staff occurred to evaluate areas of improvement to increase compliance. The screening tool was modified multiple times according to concerns that were brought up at these monthly meetings.

The screening tool was rolled out in October of 2013 and the primary outcome measure of the project was monthly compliance with completion of the tool. Compliance was measured in an all-or-none fashion, meaning both risk assessment and prophylaxis portions of the tool had to be completely filled to be considered compliant. Compliance was assessed on a monthly basis and reported as a percentage of the number of tools that reported recommendations were ordered or already in place (or that the patient was not ≥ 14 years of age and did not meet prophylaxis guidelines) divided by the total number of tools received multiplied by 100. The aim of the project was to reach 70% monthly compliance with the screening tool in the seven-month post-implementation period from October of 2013 to April of 2014.

The first PDSA cycle using the initial screening tool occurred in October of 2013 (Appendix A). The second PDSA cycle occurred from November of 2013 to February of 2014 with a revised screening tool. Nurses had asked for clarification regarding the risk factor of viral infection and the intervention of early ambulation so the tool was changed to elaborate on these areas. Additionally, the prophylaxis portion of the tool was edited with the use of rectangles for each risk category to improve algorithm flow. To decrease paper waste during this second PDSA cycle, nurses were asked to complete the tool for those ≥14 years of age rather than for all PICU patients. The third PDSA cycle occurred in March of 2014. During this cycle, the same screening tool from the second PDSA cycle was used; however, nurses were asked to return to screening all PICU patients. The fourth and last PDSA cycle occurred in April of 2014 during which nurses were asked to switch back to screening only those ≥ 14 years of age. This cycle also involved a further revised screening tool that included specific instructions on how to complete the tool, a more concise table of risk factors, and further revision of the rectangles for the prophylaxis portion of the tool.

**Results**

Review of Doppler and CTA reports for PHCH revealed 3 VTEs in 2012. All 3 VTEs were DVTs discovered by venous Doppler studies. Baseline characteristics of the three patients who sustained these VTEs are demonstrated in Table 1.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Location</th>
<th>Age</th>
<th>Gender</th>
<th>Days Post-Admission</th>
<th>CVL</th>
<th>Other RF’s</th>
<th>Prophylaxis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CH3</td>
<td>7 months</td>
<td>Female</td>
<td>10</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>CH4</td>
<td>18 years</td>
<td>Male</td>
<td>9</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>CBD</td>
<td>8 years</td>
<td>Male</td>
<td>4</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

*Number of days post-admission when VTE occurred
** Presence of a central venous catheter (CVL)
*** Risk factors other than the presence of a CVL

Patients were either located on the general pediatric wards (CH3 and CH4) or on the cancer and blood disorder unit (CBD) when their VTEs were diagnosed. Patient 1 was an ex-24 weeker admitted to the
PICU in respiratory distress. While she did not have a CVL at the time of her VTE, she did have a CVL in place for a month that was removed approximately 2 months prior to her VTE. Her VTE occurred in the same vein where her CVL had been placed. Patient 2 had a history of cystic fibrosis, diabetes mellitus, and cholestasis. He was admitted for CVL placement for antibiotic treatment of his cystic fibrosis. His VTE also occurred in the same vein where his CVL had been placed 9 days prior on admission. Patient 3 had a history of neuroblastoma and was admitted for CVL placement for chemotherapy. His upper extremity CVL was placed 3 days prior to his VTE which occurred in his ipsilateral lower extremity. Venous Doppler studies were obtained in all patients secondary to extremity swelling. None of the 3 patients received mechanical or pharmaceutical thromboprophylaxis. All patients were treated with enoxaparin for their VTEs.

Figure 1 demonstrates the incidence of VTE at PHCH. The 3 VTEs in 2012 over 38,667 patient days amounted to an incidence of 0.08 VTEs per 1,000 patient days. As of April of 2014, no VTEs have occurred at PHCH since 2012. Figure 2 displays the primary outcome measure of monthly compliance with VTE screening and prophylaxis in the PICU.

![Incidence of VTE at PHCH](image)

**Figure 1:** Incidence of VTE per 1,000 Patient Days per Year at PHCH from January 2012 to April 2014.
Discussion

Pediatric hospital-acquired VTE is a growing and costly problem\textsuperscript{1-5}. Many risk factors for pediatric VTE exist; however, few guidelines to prevent pediatric hospital-acquired VTE have been created\textsuperscript{1,6-8}. With PHCH as a member of the CHSPS which seeks to improve patient safety, the goal of this project was to take prior pediatric VTE screening and prophylaxis guidelines and incorporate them in the PICU at PHCH\textsuperscript{9-11}. The incidence of VTE at PHCH in 2012 was 0.08 per 1,000 patient days. While a low incidence, 3 patients were still harmed. Of note, all patients had risk factors previously described for VTE, including the presence of a CVL, and Patient 2 qualified for prophylaxis based on the screening tool developed for this project\textsuperscript{1,6-8}. The screening tool was incorporated in PHCH’s PICU in October of 2013. The specific aim of the project was to reach 70% monthly compliance with completion of the screening tool over the seven-month post-implementation period. The results of the study demonstrated varying degrees of compliance to the screening tool over time.

Initial compliance was high at 88% in October of 2013 and was thought to be due to initial momentum. Nursing received frequent reminders during the first month with regards to daily distribution and completion of the tool. Over the next couple of months, baseline compliance remained at 70% or higher; however, overall compliance decreased each month. By the fifth month, compliance had dropped to 33%. Of note, while the screening tool was in color on the PHCH’s intranet for reference, it was not printed in color for nursing to fill secondary to costs which may have played a role in compliance since the colors of the tables (i.e. risk factors and contraindications) correlated with the rectangles to be completed.

Issues arose at monthly meetings including incompletion of risk assessment by night shift or incompletion of the prophylaxis portion of the tool by day shift. Night shift had trouble following the risk assessment portion of the tool, as evidenced by multiple pathways being marked on the forms, and
there was lack of communication to day shift to complete their portion of the tool. Additionally, tools frequently noted that the form was not addressed on rounds. Nurse management felt that having screening tools filled for all PICU patients, regardless of age, was helpful in making use of the tool more routine. This idea seemed to prove true as a return to having all PICU patients screened in March led to an increase in compliance, and compliance decreased again in April when screening was only done for those ≥ 14 years of age. Anecdotally, it seemed without frequent reminders, as occurred in the first month of the screening tool, nurses were less likely to complete the tool altogether. Having the screening tool be part of an electronic order set would likely have led to increased compliance since most tasks are now done electronically and electronic reminders could be set. PHCH’s current electronic medical record (EMR) system was unable to implement such an order set at the time of this project. A future goal for this screening tool is to see it executed throughout PHCH via EMR perhaps through a program such as VTE Advisor which is an electronic VTE screening program used for adults.

Education on how to complete the screening tool was reviewed with nursing at monthly meetings. Screening tool revisions were made throughout this project to address concerns from monthly meetings. Changes on the latest version will hopefully improve future compliance (Appendix B). The first major change is the tool no longer asks if the form was addressed with the team on rounds. Instead, the tool asks if the form was addressed with an MD which allows for night nurses to complete the entire tool. Instructions on the top left of the tool now say night nurses are to complete the tool on all PICU patients which takes into account the suggestion made by nurse management. The goal of this modification is to have less people involved in completing the tool, resulting in fewer omissions, and hence better compliance. To aid in following the proper risk assessment path, the tool now has instructions to land in 1 of the 6 dotted rectangles and to ensure all questions in that rectangle are completed prior to returning the tool to the binder at the nurses’ station. The final change is an area on the top right of the tool for nurses to write their names. As an incentive to increase compliance, monthly prizes will be given to the nurse with the most completed screening tools. Placing names on the screening tools also allows for specific education of nurses should they be filled incorrectly.

There were several limitations of this project. First, while the future goal would be to implement a VTE screening tool throughout PHCH, it may not be feasible to have such a tool completed elsewhere in the hospital until either multidisciplinary rounds or an electronic version of the tool are implemented on the general pediatric wards. Second, the assumption was made that for every patient ≥ 14 years of age a screening tool was completed; however, there were no validation measures for this assumption with regards to compliance such as periodic census checks and surveillance to ensure all patients ≥ 14 years of age were screened. There were also no validation measures with regards to risk factors being properly assessed; for example, while compiling the data, a 14 year old child with cancer was noted not to be considered at risk. Third, secondary process measures such as sequential compression device use, pharmacologic prophylaxis ordering patterns, and physical therapy consults were not investigated. Moreover, countermeasures such as nursing time to complete tools or bleeding risks from pharmacologic prophylaxis were not measured. Lastly, while no further VTes occurred during the duration of this project, statistically, a cause-and-effect relationship between this outcome and the screening tool cannot be made.
While initial compliance was promising and demonstrated that establishing VTE screening and prophylaxis is possible at PHCH’s PICU, various issues and limitations arose. Multiple PDSA cycles required intense effort and time commitment on the part of team members. Fitting the tool into the electronic workflow of providers is likely to be a more successful strategy. As noted by Raffini et al., nursing buy-in and time to make changes can lead to success. Overall, this project demonstrated that attempting institutional change and sustainability of change is difficult; however, our aim is to continue to improve upon the screening tool itself, partner with other network hospitals, achieve electronic implementation, and maintain a low incidence of VTEs at PHCH.
References


Appendix A

PHCH VTE prophylaxis and risk assessment tool

≥14yo

Yes

Already on therapeutic or prophylactic subq LMWH or equivalent?

Yes

Does not meet routine VTE prophylaxis guidelines. Prophylaxis may still be indicated based on risk factors or at discretion of attending physician.

No

Consider:
- still indicated?
- compliance with SCDS (19h/day)?
- amb-A level needed?
- LMWH/HFH need to be held for surgery?

Yes

Altered mobility (temporary or permanent)?

Yes

Other VTE risk factors? (table 1)

No

Other VTE risk factors? (table 1)

Address on rounds

Yes

High risk

Contraindication to anticoagulation (table 2)

No

At risk

Low risk

Contraindication to anticoagulation (table 2)

Yes

No

Intervention:
SCDs 16h/day (table 3)
Rec. calib/stat

***AND***
Mobility as tolerated (Active or Passive)

Intervention:
Enoxaparin or UFH

***AND***
SCDs 16h/day (table 3)
Rec. calib/stat

***AND***
Mobility as tolerated (Active or Passive)

Intervention:
Early ambulation

***AND***
SCDs 16h/day (table 3)
Rec. calib/stat

***AND***
Mobility as tolerated (Active or Passive)

Intervention:
Early ambulation

Table 1: VTE risk factors

**ACUTE CONDITIONS:**
- Major lower extremity orthopedic surgery
- Spinal cord injury
- Major trauma to the lower extremities
- Lower extremity central venous catheter
- Cancer
- Acute infection
- Known active viral infection
- Current antibiotic treatment
- Burns
- Pregnancy

**CHRONIC MEDICAL CONDITIONS:**
- Obesity
  - weight >80 kg in 14-15yo
  - weight >85 kg >16yo
- Estrogen containing medications
- Inflammatory bowel disease
- Nephrotic syndrome
- Known acquired or inherited thrombophilia

**HISTORICAL FACTORS:**
- Previous history of DVT/PE
- Family history of VTE in 1st degree relative < 40yo

Contraindications to anticoagulation

Intracranial hemorrhage
- Acute stroke
- Ongoing and uncontrolled bleeding
- Uncorrected coagulopathy
- Allergy to pork products
- Heparin induced thrombocytopenia
- Incomplete spinal cord injury w/suspected or known paraspinal hematoma

Table 2: Contraindications to mechanical prophylaxis

- Suspected or existing DVT
- Extremity with peripheral IV access
- Skin condition affecting extremity (ex: dermatitis, burn)
- Acute fracture in extremity (CAN do SCD on other leg)

Day shift RN:
1) Select assigned risk: Doesn't meet guideline, already on it, high, low or can't risk
2) Did you address recommended prophylaxis w/team on rounds/admission? [Yes/No]
3) If yes, what was the team's response? (check one)
   - Accepted recommendation and ordered it
   - Accepted recommendation but didn't get ordered & I didn't bug them again
   - Did not accept recommendation, Why?
4) Put in notebook for RN, NOT in chart...THANKS!
5) Suggestions for improving this form?
Appendix B

Instructions: Complete one form per nightshift on all PICU patients. Follow flowchart and land in one of the dotted rectangles. Nightshift should answer all questions in the rectangle or complete and put form in VTE notebook.

PHCH VTE prophylaxis and risk assessment tool

-14yo

Yes

No

Already getting VTE prophylaxis or therapy?

Yes

No

Consider:
- still indicated?
- compliance with SCDs (16h/day)?
- anti-Xa level needed?
- LMWH/heparin need to be held for surgery?

- Addressed w/ MD
- Not addressed

Yes

No

Altered mobility (temporary or permanent)?

Yes

No

Other VTE risk factors? (Table 1)

Yes

No

Contraindication to anticoagulation? (Table 2)

Table 1: VTE Risk Factors

- Major lower extremity orthopedic surgery
- Spinal cord injury
- Major trauma to the lower extremities
- Lower extremity central venous catheter
- Cancer
- Acute infection
- Known active viral infection including respiratory
- Current antibiotic treatment
- Burns
- Pregnancy
- Obesity
- Weight > 80 kg in < 14-16yo
- Weight > 155 kg > 16yo
- Estrogen containing medications
- Inflammatory bowel disease
- Nephrotic syndrome
- Known acquired or inherited thrombophilia
- Previous history of DVT/PE
- Family history of VTE in 1st degree relative < 40yo

Table 2: Contraindications to anticoagulation

- Intracranial hemorrhage
- Neurosurgery within 48h
- Acute stroke
- Ongoing and uncontrolled bleeding
- Uncorrected coagulopathy
- Allergy to pork products
- Heparin induced thrombocytopenia
- Incomplete spinal cord injury w/suspected or known paraspinal hematoma
- Early ambulation

Intervention:

- Early ambulation

1) Has the child walked more than from the bed to chair in last 24h? Y/N
2) Do you plan for the child to walk today? Y/N
3) If child needs assistance, order PT
4) Accepted rec & ordered
5) Accepted rec but no order & I didn’t bug them again
6) Did not accept recommendation. Why?

Intervention:

- Early ambulation

1) Did you address recs w/ MD? Y/N
2) If yes, what was the recs’ response? Y/N
3) Accepted rec & ordered
4) Accepted rec but no order & I didn’t bug them again
5) Did not accept recommendation. Why?

Intervention:

- Early ambulation

1) Did you address recs w/ MD? Y/N
2) If yes, what was the recs’ response? Y/N
3) Accepted rec & ordered
4) Accepted rec but no order & I didn’t bug them again
5) Did not accept recommendation. Why?

Intervention:

- Early ambulation

1) Did you address recs w/ MD? Y/N
2) If yes, what was the recs’ response? Y/N
3) Accepted rec & ordered
4) Accepted rec but no order & I didn’t bug them again
5) Did not accept recommendation. Why?

Table 3: Contraindications to mechanical prophylaxis

- Suspected or existing DVT initially do within 24h
- Extremity with peripheral iv access
- Skin condition affecting extremity (exc. cut, burn)
- Acute fracture in extremity (CAN do SCD on other leg)

*Early ambulation = walking more than just from bed to chair or calendar day of admission (before MI) AND daily thereafter. Rec PT/OT if unconditioned, risk of deconditioning, and/or non ambulatory at baseline.