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Improving Deep Vein Thrombosis Prophylaxis With Mechanical Modalities in Surgical Intensive Care Unit

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Deep vein thrombosis remains a source of adverse outcomes in surgical patients. Deep vein thrombosis is preventable with prophylactic intervention. The success of noninvasive mechanical modalities for prophylaxis relies on compliance with correct application. The goals of this project were to create a guideline that reflected current evidence and expert thinking about mechanical modalities use, assess compliance with mechanical modalities, and develop strategies to disseminate an evidence-based guideline for deep vein thrombosis prophylaxis. **Key words:** *deep vein thrombosis prophylaxis*, *graduated compression stockings*, *guidelines*, *intermittent pneumatic compression device*, *quality improvement*, *surgery*

INCREASED attention to quality and safety in health care is encouraging nurses to base care decisions on evidence. However, it is not unusual that an examination of an organization's nursing policies and procedures reveals that traditions linger unquestioned for years and that written internal documents have not been updated despite newer evidence.[1] In our organization, a small project to initiate a unit guideline on noninvasive mechanical modalities (MM) for deep vein thrombosis (DVT) prophylaxis led the authors to a larger and more complex effort to influence practice on the basis of evidence, expert opinion, and an understanding of patient and staff preferences. From our experience as nurses, we knew that compliance with application and maintenance of MM was a long-standing issue. As we integrated our literature review with the findings from our observational study, it was clear that a revised MM for DVT prophylaxis policy with only intermittent pneumatic compression (IPC) was needed.

DEEP VEIN THROMBOSIS PROPHYLAXIS

Venous thromboembolism (VTE), comprising DVT and pulmonary embolism, affects an estimated 900 000 Americans, with approximately 300 000 resulting in death each year.[2] Postoperative VTE remains a common cause of preventable death.[3] Deep vein thrombosis

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can cause postthrombotic syndrome, a painful condition, and may be the precursor for pulmonary embolism, often a fatal outcome. In 2013, an international panel, supported by the US Agency for Healthcare Research and Quality, included interventions to improve VTE prophylaxis among the top 10 patient safety strategies for immediate adoption.[4]

Deep vein thrombosis is believed to be caused by altered physiologic mechanisms that are likely to occur with decreased mobility, surgery, and traumatic injury. These mechanisms include stasis, endothelial damage, and increased coagulation in the blood vessels (Virchow's Triad). Intermittent pneumatic compression is thought to reduce or prevent stasis through promotion of blood flow velocity and may decrease coagulation through fibrinolytic activity.[5]

The American College of Chest Physicians has tackled the issues around VTE prevention in regularly published guidelines. The most recent guidelines from 2012, referred to as the *Chest* guidelines throughout the rest of this article, recommend pharmacologic prophylaxis with anticoagulants for most high risk and some moderate risk hospitalized patients. However, anticoagulation may not be an option for surgical, trauma, and other patients at high risk for bleeding. For these patients, the *Chest* guidelines recommend MM prophylaxis as nonpharmacologic methods for VTE prophylaxis.[6] Two types of MM for DVT prophylaxis are used in the clinical setting: graduated compression stockings (GCS) and IPC. Intermittent pneumatic compression devices include inflatable leg sleeves that are wrapped and secured around the legs (calf alone or calf and thigh) or foot pumps/cuffs.

The *Chest* guidelines found the following variations in the research for both IPC and GCS: the length of stockings or leg sleeves used for the studies, a mixture of MM device study methodologies, and patient populations. These guidelines also noted the weak evidence behind MM, especially GCS.[6] After weighing the existing evidence, the *Chest* guidelines recommend IPC for most nonorthopedic surgical patients and for all orthopedic patients.[3,7] In 2011, the American College of Physicians advised against the use of GCS in any hospitalized patients and cited weak evidence for efficacy.[8]

PRACTICE

In our organization, a nurse completes a DVT risk factor screening on hospital admission. The physician orders the GCS and IPC for patients, and the nurse insures the proper selection, application, and continuous monitoring of all MM.[6] Continuous surveillance for signs and symptoms of DVT is also a part of nursing care. If the efficacy of MM for DVT prophylaxis is to be optimized, risk assessment, compliance with the written order, and vigilant monitoring of proper application and function of these devices need to be systematically documented.

The literature suggests that MM have been inconsistently applied and monitored in the clinical setting.[9-13] In our organization, practice was confusing and lacked supporting evidence. One of the authors (P.R.) became concerned that the lack of a guideline might be contributing to confusion about DVT prophylaxis and fostering variation in practice in the surgical intensive care unit (SICU). This was the motivation for this project.

Consultations with nurses and physicians familiar with DVT prophylaxis led to the conclusion that the topic was of importance to patient safety in the SICU, a 20-bed unit that cares for critically ill surgical and trauma patients, and in the organization. The authors identified the opportunity for developing a standardized evidence-based guideline for the use of IPC for DVT prophylaxis to promote quality improvement for patients' safety. Therefore, the goals of this project were to (1) assess compliance with MM pre- and postguideline implementation; (2) create a guideline and an organizational procedure that reflects current evidence and best practices for IPC use; and (3) use strategies to disseminate an evidence-based guideline for DVT prophylaxis.

METHODS

The first goal was to assess compliance with use of MM pre- and postunit guideline implementation. All patients in the SICU were observed over a 3-week period, with the postunit observation completed after guideline implementation and education.

Observations were done twice a day to assess whether the GCS and/or IPC devices were being used. To identify practice issues, we conducted focus groups with SICU nurses. The Human Research Committee approved this observation study and the focus groups.

Procedure

During the procedure for the first goal, the pre- and postguideline observation, the investigators reviewed each patient's medical record for demographic and clinical data, including MM physician orders in the SICU. In the weeks after the preguideline observations, 3 focus groups of SICU nurses (n = 25) met with a facilitator and sessions were audiotaped. The focus groups asked how nurses knew when MM were ordered, their perceived barriers to and support for use of the MM, how patients and family members are educated about DVT and MM, and how communication about MM occurs across all members of the health care team.

Analysis

Data for the first goal on compliance were analyzed using the Statistical Package for the Social Sciences (SPSS), version 19.0 (IBM, Inc, Somers, New York). Descriptive statistics were used to test assumptions, compute and compare demographic and clinical variables, physician orders, and the presence of GCS and/or IPC. The level of significance was set at $P < .05$.

The primary outcome assessed was compliance with the GCS and/or the IPC. A compliance score was calculated by dividing the number of compliant evaluations, those with devices correctly placed on the patient and the power source turned on and functioning, by the total number of observations. Based on a previous compliance study, the authors established a score below 75% as indicative of poor compliance in a 2-tiered poor/good scale.[13]

The second goal was to create a unit guideline and an organizational procedure for MM. The investigators reviewed literature and consulted with experts in DVT prophylaxis. The literature search was performed in the MEDLINE/PubMed and CINAHL databases for the years 1984 to 2009, and an alert for new articles was maintained in PubMed through November 2013. Methodology included, but was not limited to, the use of Medical Subject Headings (MeSH) and CINAHL Headings as well as key word searches.

The authors sought expert opinions and clarifications of specific issues from national and international researchers in the field of DVT and MM. In addition, the principal investigator requested and received permission for team members to view the training materials created online by the CLOTS Collaborative Trials (United Kingdom), whose international multicenter trials examined MM in poststroke patients.[14,15] Although these studies examined MM in a nonsurgical population, the CLOTS Trials have strongly influenced current thinking about MM in all hospitalized patients. The authors then created an evidence-based unit guideline for DVT prophylaxis with IPC in the SICU. The guideline was organized into several parts: review of terms/definitions, DVT assessment, indications/uses, and frequently asked questions. A procedure for the use of IPC was submitted and approved by the organization's nursing practice committee.

The third goal was to formulate strategies to disseminate the unit guideline. Using our synthesis of the literature with the personal communications from key physician stakeholders at our organization as well as from global experts, the investigators created an educational package that included pertinent literature, a presentation for staff members, and a SICU evidence-based guideline. The IPC educational program for the SICU was accomplished in stages after the development of a unit-based guideline. We collaborated with the unit nurse director, clinical nurse

specialist, medical director, and attending anesthesiologists and surgeons.

RESULTS

For the first goal, there were 95 patients pre- and 92 patients postunit guideline in the observation period. Demographic and clinical service data are displayed in Table 1. There were more trauma patients during preobservation, as these data collection occurred during summer, a time known for increases in trauma-related injuries. The pharmacologic DVT prophylaxis was used in the majority of patients (Table 1).

Once the patient was admitted to the SICU from the operating room or emergency department, the physician's orders were written as per hospital standard. Table 2 displays physician's orders/actual presence of MM for the first observation pre- and postguideline in the SICU.

Compliance assessment

Preguideline, the patients were in the SICU for a mean of 3.58 ± 3.1 days, with a range between 1 and 21 days for a total of 560 observations with 441 compliant observations (79%). Postguideline, the patients were in the SICU for a mean of 3.86 ± 3.7 days, with a range between 1 and 21 days for a total of 645 observations with 498 compliant observations (77%). Based on the scoring system used in this study, these data indicate good compliance with MM in the SICU pre- and postobservations.

During preobservation period, there was a 93% compliance rate specifically with IPC and a 51% compliance rate with GCS. During postobservation, there was an increase in compliance with the use of IPC (128%) and GCS (67%) although IPC and GCS were ordered less frequently. There was also a statistically significant increase in the number of patients without physician's orders for IPC in the post observation (Table 2).

Focus group concerns

Twenty-five nurses participated in 3 focus groups. The mean age of the sample group was 38.5 ± 12 years (21 females, 4 males). Years worked in the SICU and years in clinical practice were 12.6 ± 11.7 years and 15.6 ± 12.8 years, respectively. A majority (88%) of

Table 1. Demographic Variables, Clinical Service, and Pharmacologic Prophylaxis Pre- and Postguideline Implementation

N (Patients)	Predata 95	Postdata 92	*P*
Dates of Observations	August 1, 2010 to August 21, 2010	February 9, 2012 to February 29, 2012	
Age (mean years ± standard deviation)	61.4 ± 15.2	60.9 ± 15.6	.83
Gender (males/females)	59/36	64/28	.18
Days of observation	3.58	3.86	.58
Service			.01
Trauma	21	6	
General surgery	21	21	
Vascular	22	18	
Thoracic	15	22	
Other surgical services	16	25	
Pharmacologic DVT Prophylaxis on Admission	60	53	.45

Abbreviation: DVT, deep vein thrombosis.

Table 2. Physician's Orders and Presence of Mechanical Modalities on First Observation Pre- and Postunit Guideline

	PreData (n = 95)		Postdata (n = 92)	
	Orders n	Device On n (%)	Orders n	Device On n (%)
IPC[a]	70	65 (93)	49	63 (128)
GCS[a]	49	25 (51)	31	21 (67)
No orders[b]	12		38	
Device not on appropriately		13 (1.4)		14 (1.6)

Abbreviations: GCS, graduated compression stockings; IPC, intermittent pneumatic compression devices.
[a]Numbers reflect use of both devices on 36 pre- and 26 postpatient observations.
[b]$P = .025$.

the nurses were baccalaureate-prepared nursing graduates.

During focus group sessions, the SICU nurses discussed varying practices regarding the use of MM. Of particular worry was the potential loss of skin integrity with GCS as well as the potential for limb constriction in patients with lower extremity edema. Other concerns included lack of clarity on use of MM with use of anticoagulants, the use of MM in the presence of an intravenous catheter in the lower extremity, and the need for verification of the absence of a DVT before placing MM on patients. The nurses also identified other issues associated with MM: the use of IPC with existing DVT, combined use of GCS/IPC, thigh versus knee length IPC, and application of IPC in only 1 limb.

Nurses reported that assessment of skin integrity is hampered by the use of GCS. Nurses also asked whether IPC should be used while patients are out of bed and how long IPC can be off for patient care to maintain its benefit. Nurses reported that accurate sizing and fit of MM is difficult, especially for the bariatric patient. These issues and concerns were defined as areas that needed to be addressed in the guideline and education.

DISCUSSION

The observational study in this project demonstrated that the overall compliance with use of MM, 79% pre- and 77% postunit guideline, was good using the benchmark of greater than 75%.[13] Our educational efforts with the unit guideline did not change the post compliance rate. However, reviewing the data for each modality separately revealed a different story and led us to look for additional ways to change practice.

In our preguideline observations, almost half of the patients had no GCS applied despite having orders. Added analysis of patient records suggested that within hours of arrival in the SICU, the patients' GCS were removed and not replaced. In the postguideline period, only one-third of patients had no GCS applied despite having orders. Of note, there was an 18% reduction of GCS orders in the postguideline observation.

Winslow and Brosz[12] had found that more than 25% of GCS were not sized and/or used correctly. Graduated compression stockings requires careful measurement of calf circumference and leg length that requires multiple size options that may not always be available. Our preguideline observations confirmed that nursing staff were not consistently using GCS.

Throughout the work on this project, we realized that there were concerns about GCS. The intensive care unit population experiences fluctuation in fluid balance, resulting in potential for peripheral edema, and it is rare that GCS is readjusted and/or resized. In fact, the term "tourniquet effect" is frequently used

to describe the phenomenon of leg constriction because of tightened GCS from peripheral edema. Graduated compression stockings inhibits assessment of skin integrity and peripheral pulses.[12]

Prior studies of IPC use showed overall compliance rates ranging from 48% to 85%.[9-11,13] In our study, prior to the SICU guideline, nurses complied with 93% use of IPC. In the preguideline period, there was a decrease in physician's orders for IPC from 74% to 53% of patients, but there was an increase in patients with IPC use to 128%. That is, patients were wearing devices without physician's orders. These data revealed a change in nursing practice for DVT prophylaxis while identifying the need for further collaboration with our physician colleagues regarding IPC orders.

Of particular concern was the rise in patients without orders for MM: 13% preguideline to 41% postguideline. We hypothesized that this may be related to the "unfreezing" of traditional views of DVT prophylaxis with MM in the course of the change process. One author (P.R.) noted more questions from physicians and nurses regarding appropriate DVT prophylaxis. Given that more than one-third (40% pre and 47% post) of critically ill patients in our study did not have pharmacologic prophylaxis, the use of MM is even more important.

Based on the review of the focus group discussion, the SICU nursing staff expressed lack of understanding about the potential efficacy of MM for surgical patients, and there was uncertainty in the proper use of these devices to prevent DVT. Nurses articulated specific concerns and questions, some reflected in the literature.[10-12] Other concerns were not covered in previous compliance studies, for example, the "prior bed rest" rule related to potential for presence of DVT, requiring delay in application of IPC despite lack of clinical signs of DVT.

We believed originally that an updated, clearly written unit guideline and an organization-wide procedure on IPC with staff education would be sufficient to change practice and improve compliance with MM. Some researchers have concluded that educational strategies alone are inadequate. We too realized that we had gaps in the translation from evidence to practice with only our educational efforts.[9,16]

During consultation with colleagues, we identified the need for a more robust buy-in from organizational leaders. We began by discussing our work with the physician chief of quality for the surgical service because physicians were still ordering GCS and IPC. The literature did not support an added benefit to combining GCS and IPC.[5] The literature review and unit guideline were presented to the physician surgical quality leaders who then unanimously agreed to remove GCS from surgical order sets on the basis of the evidence. With the GCS orders removed from physician order templates, we returned to nursing leaders and key staff with a new organizational IPC procedure for MM. This procedure was approved by the nursing policy and procedure committee. With this approval, the authors continued to use opportunities to present to other committees, journal clubs, and at unit practice meetings in our effort to get the word out about IPC procedure.

Nurse-to-nurse, nurse-to-physician, and nurse-to-patient and family member communication at the bedside and discussions about practice change became invaluable in influencing unit standards. The organization-wide procedure provides the evidence to continue to change practice throughout the organization. Further audits could provide continuous feedback to raise awareness of best practice for MM prophylaxis.

Limitations

There are limitations in this project. Our data definitions were not initially clear and needed to be refined during the course of study. The involvement of multiple data collectors may have also influenced our results. We did extensive literature reviews although there may have been evidence that we missed. This study was completed in an intensive care unit and may not reflect practice on medical-surgical units. Therefore, these results may not be generalizable to these units.

CONCLUSIONS

Changing MM practice for DVT prophylaxis required a comprehensive review of the evidence from a multidisciplinary perspective. We achieved change through interacting with the multiple system layers of the organization. In summary, we were able to study preexisting practice and successfully implement evidence-based guidelines to promote confidently the use of IPC for DVT prophylaxis in our organization. The future goals and challenges for practice include (1) measuring the success, (2) maintaining staff awareness, and (3) raising the standard for compliance. It is more than regulation, financial aspects, or even mission statements that encourage change in an organizational culture. Change requires that people remain passionate about providing the best care for patients.

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