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Comparison of strategies for adherence to venous thromboembolism prophylaxis in high-risk surgical patients: a before and after intervention study

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ABSTRACT

Background Venous thromboembolism (VTE) is a major cause of perioperative morbimortality. Despite significant efforts to advance evidence-based practice, prevention rates remain inadequate in many centres.

Objective To evaluate the effectiveness of different strategies aimed at improving adherence to adequate VTE prophylaxis in surgical patients at high risk of VTE.

Method Before and after intervention study conducted at a tertiary hospital. Adherence to adequate VTE prophylaxis was compared according to three strategies consecutively implemented from January 2019 to December 2020. A dedicated hospitalist physician alone (strategy A) or in conjunction with a nurse (strategy B) overlooked the postoperative period to ensure adherence and correct inadequacies. Finally, a multidisciplinary team approach (strategy C) focused on promoting adequate VTE prophylaxis across multiple stages of care—from the operating room (ie, preoperative team-based checklist) to collaboration with clinical pharmacists in the postoperative period—was implemented.

Results We analysed 2074 surgical patients: 783 from January to June 2019 (strategy A), 669 from July 2019 to May 2020 (strategy B), and 622 from June to December 2020 (strategy C). VTE prophylaxis adherence rates for strategies (A), (B) and (C) were (median (25th–75th percentile)) 43.29% (31.82–51.69), 50% (42.57–55.80) and 92.31% (91.38–93.51), respectively (p<0.001; C>A=B). There was a significant reduction in non-compliance on all analysed criteria (risk stratification (A (25.5%), B (22%), C (6%)), medical documentation (A (68%), B (55.2%) C (9%)) and medical prescription (A (51.85%), B (48%), C (6.10%)) after implementation of strategy C (p<0.05). Additionally, a significant increase in compliance with adequate dosage, dosing interval and scheduling of the prophylactic regimen was observed.

Conclusion Perioperative VTE prophylaxis strategies that relied exclusively on physicians and/or nurses were associated with suboptimal execution and prevention. A multidisciplinary team-based approach that covers multiple stages of patient care significantly increased adherence to adequate VTE prophylaxis in surgical patients at high risk of developing perioperative VTE.

INTRODUCTION

Pulmonary embolism secondary to venous thromboembolism (VTE) is a serious complication in surgical patients. In addition to being the most frequent cause of preventable death in this population, VTE is a leading cause of cardiovascular death along with coronary artery disease and stroke.[1]

Thromboprophylaxis is the most effective strategy to reduce perioperative VTE. However, approximately 50% of at-risk patients receive no (or suboptimal) pharmacological prophylaxis.[2] Reported VTE prophylaxis compliance rates are highly variable and depend on technical knowledge of local healthcare providers, and whether there are clear and well-defined processes in place to promote adequate prophylaxis.[3] In 2008, Brazil had non-compliance rates of 54% among surgical patients.[4]

Different approaches have been attempted to improve adherence to VTE prophylaxis. Didactic education, passive dissemination of evidence-based guidelines and strategies aimed at correcting errors that have already occurred have proven ineffective.[5 6] Improving adherence requires creative and repetitive educational strategies, alert systems, audits, and ongoing analysis and management of all stages related to perioperative VTE prophylaxis through a multidisciplinary team approach.[7 8] Many strategies currently in place, however, rely exclusively on the performance of healthcare professionals (with or without the aid of alert systems) to ensure adequate risk stratification and

adherence to prophylaxis which often results in suboptimal prevention.[8]

This study sought to compare the effectiveness of three strategies aimed at improving adherence to perioperative VTE prophylaxis that were consecutively implemented over a 2-year period. We hypothesised that a multidisciplinary team approach covering several stages of patient care would result in improved adherence to optimal VTE prophylaxis compared with a physician (alone or in conjunction with nursing)-based intervention.

METHOD

This was a single-centre before and after study conducted at a Brazilian tertiary hospital between January 2019 and December 2020. This historical series compared three strategies consecutively implemented aiming to improve adherence to perioperative VTE prophylaxis.

All adult surgical patients at high risk of perioperative VTE were included. High risk was defined as[9]: patients >40 years old, undergoing major surgeries (eg, joint replacements, abdominal/thoracic procedures, brain/spine surgeries) with duration >60 min, staying in hospital for ≥2 days, and/or with associated risk factors for VTE (cancer, active inflammatory bowel disease, severe respiratory disease, congestive heart failure, history of VTE, active infection, peripheral arterial and/or venous insufficiency, intensive care unit admission, obesity, hormone replacement, active nephrotic syndrome and thrombophilia). Patients undergoing surgical procedures deemed high risk of VTE (hip/knee arthroplasty, hip fracture, oncological procedures, spinal cord trauma and/or polytrauma) were included regardless of age and/or presence of other risk factors. Patients classified as low and intermediate risk for VTE[9] were excluded from the final analysis, as were those on previous anticoagulants.

The impact of all three strategies was analysed according to institutional policy. Data collection began in January 2019 and involved monthly audits of medical records from surgical patients at high risk of perioperative VTE. Data pertaining to pharmacological VTE prophylaxis were collected at three stages of patient care: (1) initial 24 hours postoperative; (2) maintenance of prophylaxis during hospital stay and (3) extended (ie, post-discharge) prophylaxis. At each stage, details of the pharmacological prophylactic regimen (ie, medication(s), dosage, dosing interval), and relevant documentation in the medical chart were recorded and considered our adherence/compliance criteria. Monthly compliance was then calculated using the number of patients fulfilling all compliance criteria at the three stages of data collection (numerator) divided by the total number of patients at high risk of perioperative VTE (denominator). Data on mechanical prophylaxis (ie, graduated compression elastic stockings and/or intermittent pneumatic devices), although not included as part our compliance criteria, were also recorded. Contraindications to mechanical prophylaxis included conditions affecting the lower limbs (severe peripheral vascular disease and/or ulcers; recent skin graft; recent peripheral arterial bypass grafting; severe lower limb oedema, local gangrene/infected wounds, dermatitis, fragile 'tissue paper' skin), pulmonary oedema secondary to congestive heart failure and known allergy to the material/fabric used in mechanical prophylaxis devices. Notably, throughout the 2 years of data collection, pharmacological prophylaxis at our institution, when indicated, was started in the postoperative period, with intraoperative mechanical prophylaxis applied according to risk stratification at the discretion of the attending surgeon. Contraindications to pharmacological prophylaxis were defined according to the American College of Chest Physicians (ACCP).[9] Documented refusals from the attending physician(s) and/or clinical contraindications to pharmacological VTE prophylaxis were not included in the calculation of monthly compliance.

Throughout data collection, information containing the monthly compliance rates was displayed on a dashboard to keep stakeholders updated and to encourage adherence to perioperative VTE prophylaxis. All medical records of surgical patients at high risk of VTE were reviewed by a nurse responsible for collecting compliance data. These preliminary data were then validated and subsequently analysed by a local group dedicated to updating and optimising the institutional VTE prophylaxis protocol.

The institutional VTE prophylaxis protocol described below is routinely applied to all surgical patients and was followed during the entire study period. On hospital admission, preoperative risk stratification based on the ACCP guidelines[9] is carried out by a nurse who informs the surgical team of the institutional recommendation on pharmacological ±mechanical prophylaxis. The prophylactic regimen is ultimately defined by the attending surgeon who can (1) accept the institutional recommendation, (2) modify or (3) withhold the recommended regimen altogether based on clinical reasons. Importantly, once a decision is made, it must be documented by the surgeons using the institutional VTE prophylaxis form (in which deviations from the recommended regimen can be justified). Subsequently, the prescribed prophylactic regimen is followed throughout hospital admission and after discharge. Notably, since the risk of VTE may change, daily reassessment by a nurse is recommended for all surgical patients during hospitalisation. The institution does not have an electronic medical record; thus, all data are recorded manually.

For patients at high risk of developing perioperative VTE, any of the following pharmacological regimens (generally starting 4 hours postoperatively) were deemed adequate (compliant) according to institutional policy: unfractionated heparin 5000 IU subcutaneously (SC) every 8 hours, enoxaparin 40 mg SC daily, dalteparin 5000 IU SC daily, nadroparin 1900–3800 IU SC daily, fondaparinux 2.5 mg SC daily, dabigatran 220 mg orally daily and rivaroxaban 10 mg orally daily.

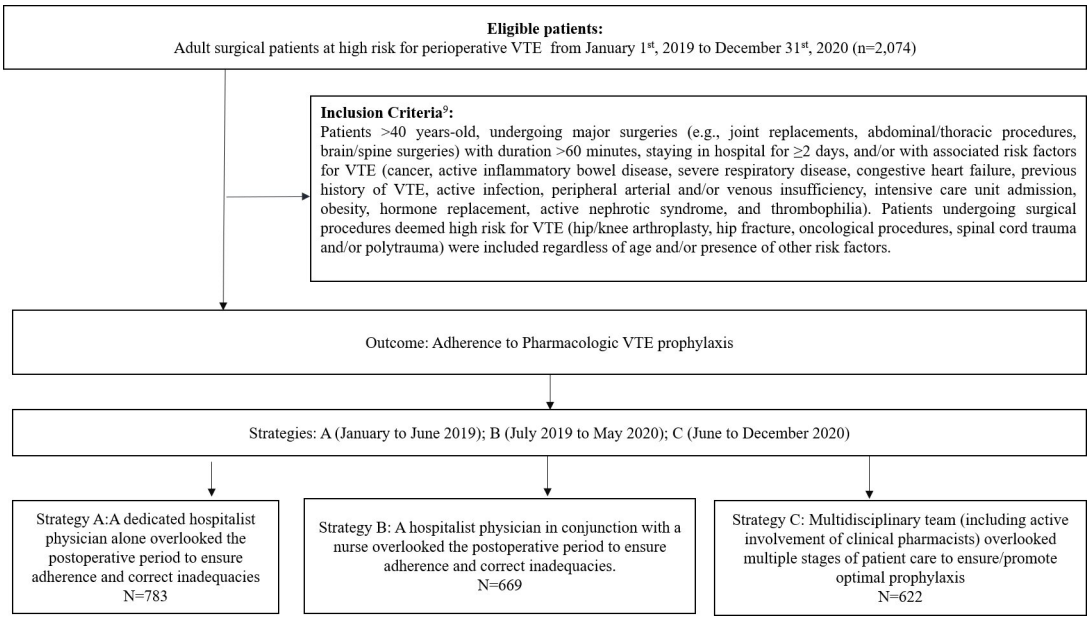

Figure 1 Diagram showing eligibility, inclusion criteria and distribution of patients according to three strategies ((A), (B) and (C)) consecutively implemented between January 2019 and December 2020 aimed to improve adherence to adequate venous thromboembolism (VTE) prophylaxis in surgical patients at high risk of perioperative VTE.

The interventions implemented in this historical series included three consecutive strategies aimed at improving adherence to the institutional perioperative VTE prophylaxis protocol, as follows (figure 1):

Strategy (A): optimising adherence to perioperative VTE prophylaxis through a dedicated hospitalist physician overlooking the postoperative period

A dedicated hospitalist was in charge of identifying postoperative patients at high risk of developing perioperative VTE who had not been prescribed a prophylactic regimen, as well as those whose prophylactic regimen deviated from the institutional recommendation. In such instances, the hospitalist actively communicated with the attending surgeon to discuss his findings and (upon agreement with the surgical team) implement adequate prophylaxis as per the institutional protocol in effect. Cases were identified by screening the daily surgical schedule or upon request by the primary healthcare team. This strategy was in effect from January to June 2019.

Strategy (B): optimising adherence to perioperative VTE prophylaxis through a dedicated hospitalist physician in conjunction with a nurse overlooking the postoperative period

A dedicated team (hospitalist +nurse) was in charge of identifying postoperative patients at high risk of developing perioperative VTE who had not been prescribed a prophylactic regimen, as well as those whose prophylactic regimen deviated from the institutional recommendation. Again, they also screened patients at the request of the primary healthcare team. In such instances, a team member actively communicated with the attending surgeon to discuss his/her findings and implement adequate prophylaxis as per the institutional protocol. In addition, patients were reassessed daily to ensure correct (ongoing) risk stratification. Upon agreement with the surgical team, the prophylactic regimen was updated and approved by the hospitalist physician. This strategy was in effect from July 2019 to May 2020. Didactic training sessions related to the VTE prophylaxis protocol in effect were offered throughout the respective time period in an attempt to improve stakeholders' understanding and interest in the subject.

Strategy (C): optimising adherence to perioperative VTE prophylaxis through a multidisciplinary team overlooking multiple stages of patient care

Discussion around VTE prophylaxis was incorporated into the surgical safety checklist that is routinely performed prior to induction of anaesthesia by a multidisciplinary team (anaesthesiologist, surgeon, operating room nurse and allied personnel). This initial step aimed to prevent patients at high risk of developing VTE from being sent to the postoperative inpatient unit without a documented prophylactic regimen. Also, patients had their initial risk stratification confirmed or modified in the immediate postoperative period based on surgical time (in cases where the duration of the procedure exceeded the preoperative scheduled time) and estimated blood loss and volume replacement. This was done by a dedicated nurse in the post-anaesthetic care unit (PACU) who also checked the medical chart to ensure that the prescribed VTE prophylactic regimen was in line with the updated risk stratification. Postoperatively, the prophylactic regimen was followed daily (and updated according to risk stratification) by a dedicated clinical pharmacist. When inconsistencies were identified, the clinical pharmacist contacted the medical team and recommended modifications to

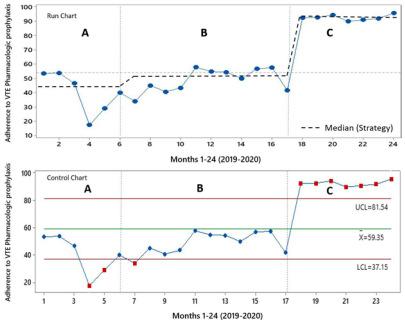

Figure 2 Run chart and statistical process control chart showing quality improvement regarding adherence to venous thromboembolism (VTE) pharmacological prophylaxis in patients at high risk of developing perioperative VTE from January 2019 to December 2020. Three strategies ((A), (B) and (C)) aimed to improve adherence were consecutively implemented during this historical series. A dedicated hospitalist physician alone (strategy A) who subsequently worked in conjunction with a nurse (strategy B) actively overlooked the postoperative period to ensure adherence and correct inadequacies. Finally, a multidisciplinary team (including active involvement of clinical pharmacists) overlooked multiple stages of patient care to ensure/promote optimal prophylaxis (strategy C). Dashed lines (run chart) represent the median adherence to VTE pharmacological prophylaxis according to each strategy within the respective time period that they were in effect. LCL, lower control limit; UCL, upper control limit; $\bar{x}$, mean (control chart).

the prophylactic regimen. Once accepted, the medical prescription was updated accordingly and the updated regimen was documented in the medical chart. The roles of the clinical pharmacist included: recommendation of pharmacological agent(s), dose/interval adjustments, route of administration, clarification of questions/concerns from the primary care team and, ultimately, discussion of the best prophylactic regimen individually tailored to each patient's needs and risk stratification. All interventions by clinical pharmacists were compiled monthly, including cases of surgeon's refusal to the recommended changes. At discharge, recommendations regarding the most appropriate prophylactic regimen by the clinical pharmacist for extended VTE prophylaxis were made to strengthen the institutional process of safe discharge. Specific team training on the steps of this strategy took place in May and June 2020, and included anaesthesiologists, hospitalists, nurses, nursing technicians and pharmacists. For logistical purposes, training for surgeons was made available electronically through a Problem Based Learning methodology,[10] followed by a post-test for evidence of training effectiveness. This multidisciplinary strategy was in effect from June to December 2020.

This report is in compliance with the Standards for Quality Improvement Reporting Excellence[11] guidelines.

Patient and public involvement

There was no patient and public involvement in the design of this project.

Statistical analysis

The measure of central tendency and dispersion for the monthly indicators analysed in the historical series was the median and 25th–75th percentiles after analysing the distribution in the normality curve. The strategies used were compared using the median of the monthly indicators of pre-implementation and post-implementation adherence. Continuous analysis was done on statistical process control charts to evaluate the trend of VTE prophylaxis, and the process measures. A Kruskal-Wallis analysis of variance was used for multiple comparisons between study periods delimited by interventions A, B and C, followed by Dunn's post-hoc test if $p<0.05$. A 95% CI and p value of <0.05 represented statistical significance. Statistical analysis was performed using the SPSS V.20.0 (SPSS Inc).

RESULTS

In total, 2074 surgical patients were analysed: 783 patients from January to June 2019 (strategy A), 669 from July 2019 to May 2020 (strategy B), and 622 from June to December 2020 (strategy C). The mean age was 57±19.9 years and 51% were female. The median adherence rates to pharmacological prophylaxis for strategies (A), (B) and (C) were 43.29% (31.82–51.69), 50% (42.57–55.80) and 92.31% (91.38–93.51), respectively ($p<0.001$; C>A=B) (figure 2). As for mechanical prophylaxis, the median adherence rates were: strategy (A) 26.5% (18.10–33.32), strategy (B) 36.16% (21.17–41.50) and strategy (C) 84% (82.5–86.5) ($p<0.001$; C>A=B) (figure 3). Strategy (C) was associated with superior median adherence to both pharmacological and mechanical prophylaxis compared with the previously implemented strategies (figure 4). For patients undergoing joint replacements, the median adherence rates to pharmacological prophylaxis for strategies (A), (B) and (C) were 93.5% (87.0–100.0), 100% (94.5–100) and 100% (100–100), respectively ($p=0.14$).

Table 1 shows the reasons for non-adherence to adequate perioperative VTE prophylaxis observed during this historical series. The most commonly observed causes for non-adherence were incomplete medical documentation (ie, lack of information on prophylactic decision recorded in the institutional VTE prophylaxis protocol sheet) and absence of medical prescription of a prophylactic regimen. There was a significant improvement in all analysed criteria after implementation of strategy C (table 1).

The clinical pharmacists contributed to significantly improve adherence to perioperative VTE prophylaxis by actively identifying inconsistencies and suggesting modifications to the postoperative prophylactic regimen. As a result, inconsistencies related to medication(s), dosage and dosing interval were significantly reduced after

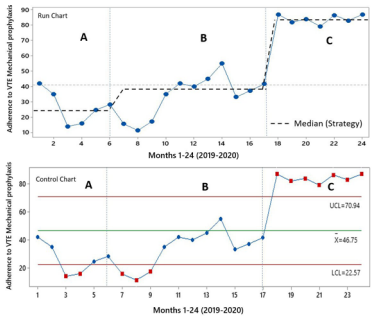

Figure 3 Run chart and statistical process control chart showing quality improvement regarding adherence to venous thromboembolism (VTE) mechanical prophylaxis in patients at high risk of developing perioperative VTE from January 2019 to December 2020. Three strategies ((A), (B) and (C)) aimed to improve adherence were consecutively implemented during this historical series. A dedicated hospitalist physician alone (strategy A) who subsequently worked in conjunction with a nurse (strategy B) actively overlooked the postoperative period to ensure adherence and correct inadequacies. Finally, a multidisciplinary team (including active involvement of clinical pharmacists) overlooked multiple stages of patient care to ensure/promote optimal prophylaxis (strategy C). Dashed lines (run chart) represent the median adherence to VTE mechanical prophylaxis according to each strategy within the respective time period that they were in effect. Mechanical prophylaxis was not included as part of our adherence/compliance criteria for perioperative VTE prophylaxis. LCL, lower control limit; UCL, upper control limit; $\bar{x}$, mean (control chart).

implementation of strategy C (p<0.05) (table 1). Specifically, incorrect dosage and inadequate dosing interval accounted for 23% and 77% of medication inconsistencies, respectively. There were no serious events (eg, death, major bleeding/adverse reactions, etc) reported as a result of medication inconsistencies. Notably, when strategy C was first implemented, 53.44% of surgical

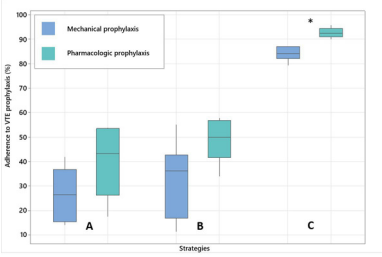

Figure 4 Adherence to venous thromboembolism (VTE) prophylaxis in patients at high risk of developing perioperative VTE was compared according to strategies consecutively implemented from January 2019 to December 2020. Box-plot: median (percentile 25%–75%). Strategy (A): a dedicated hospitalist physician overlooked the postoperative period to ensure adherence; strategy (B): a dedicated team (hospitalist physician in conjunction with a nurse) overlooked the postoperative period to ensure adherence; strategy (C): a multidisciplinary team (including active involvement of clinical pharmacists) overlooked multiple stages of patient care to ensure/promote adherence to prophylaxis. *Kruskal-Wallis: p<0.001; Dunn's post-hoc test: C>A and B; A=B.

patients at high risk of VTE required intervention by clinical pharmacists to ensure adherence to the institutional VTE prophylaxis protocol. In the ensuing months, the need for intervention significantly decreased to 8.47% in December 2020 (p=0.002) (figure 5). Overall, interventions from clinical pharmacists were directed more often towards surgeons than nurses (p=0.01) (figure 5). During the time period that strategy C was in effect, the median adherence by surgeons to suggestions/modifications made by clinical pharmacists was 75% (66.67–100). In addition, surgeons refused to adhere to the recommended institutional prophylactic regimen in 17.85% (0–29.43) of cases, and provided a clinical justification for non-adherence in 3.8% (0–7.14).

DISCUSSION

Adherence to optimal perioperative VTE prophylaxis remains a global challenge.[3 4] The main finding of this study was that a multifaceted strategy based on active engagement of a multidisciplinary team along multiple stages of patient care significantly improved adherence to optimal perioperative VTE prophylaxis in high-risk patients. Some key facets of this strategy included (1) implementation of routine risk stratification on hospital admission, (2) inclusion of perioperative VTE prophylaxis as a mandatory topic in the preoperative surgical checklist, and (3) collaboration with clinical pharmacists to provide ongoing monitoring and support in the postoperative period.

Previous studies in Brazil have demonstrated that among hospitalised patients with an indication for VTE prophylaxis, only 20%–46% received a prophylactic regimen considered adequate.[4 5 12] Notably, lack of correct risk stratification was identified as the most frequent error leading to inadequate VTE prophylaxis.[5] Globally, however, 58.5% of surgical patients were prescribed adequate perioperative VTE prophylaxis when multiple countries with different socioeconomic conditions were taken into account, with rates ranging from 92% in Germany, to staggering 0.2% in Bangladesh and Thailand.[4] In the present investigation, adherence to perioperative VTE prophylaxis during the implementation of strategies A and B was similar to that found in previous studies.

The Science of Healthcare Improvement has gained significant traction in recent years.[12] It is an area focused primarily on the development and assessment of interventions aimed at improving quality of care. One of its main goals is to explain in detail how such interventions are developed and which factors are associated with their successful implementation.[13 14] In this context, even though strategies A and B aimed to promote corrective measures in institutional processes to ensure adherence to perioperative VTE prophylaxis, they ultimately did not result in relevant improvement when compared with previously reported data across several Brazilian institutions.[4]

Table 1 Reasons for non-adherence to adequate perioperative VTE prophylaxis distributed according to the strategies (A, B and C) consecutively implemented over this 2-year historical series

Non-adherence	Strategy (A) (n=783)	(B) (n=669)	(C) (n=622)	P value*
Lack of risk stratification	25.5 (23.9–31.2)	22 (17–29.5)	6 (3.5–13)	<0.001
Incomplete medical documentation*	68 (66.7–70.5)	55.2 (48.3–58)	9 (5.14–11)	<0.001
Absence of medical prescription	51.85 (45.6–64.1)	48 (43.3–54.4)	6.10 (5.5–8.4)	<0.001
Inadequate medication(s), dosage, dosing interval	3.8 (3.3–4.65)	3 (2.1–4.1)	0.5 (0–1.75)	0.001

Values expressed as median (percentile 25%–75%). Kruskal-Wallis: p<0.001; Dunn's post-hoc test: C>A and B; A=B. Strategy (A): a dedicated hospitalist physician overlooked the postoperative period to ensure adherence; strategy (B): a dedicated team (hospitalist physician in conjunction with a nurse) overlooked the postoperative period to ensure adherence; strategy (C): a multidisciplinary team (including active involvement of clinical pharmacists) overlooked multiple stages of patient care to ensure/promote adherence to prophylaxis.
*Lack of information on prophylactic decision.
VTE, venous thromboembolism.

As observed (mainly) with strategies A and B, common shortcomings associated with inadequate VTE prophylaxis include failure to prescribe/administer prophylactic medications and/or the administration of inadequate prophylaxis, which have been reported in 19% of surgical patients in Brazil.[5] With strategy C, however, the active engagement of clinical pharmacists allowed for ongoing adjustment of the prophylactic regimen based on daily risk (re-)stratification. In addition, this strategy also captured and immediately corrected those (rare) patients who left the operating room without a prophylactic regimen in place. Indeed, the (1) proactive decision-making in the operating room combined with (2) active surveillance in PACU, and (3) continued involvement of clinical pharmacists in the postoperative period proved most effective in ensuring adherence to perioperative VTE prophylaxis.

Many approaches have been attempted to improve adherence to VTE prophylaxis.[6 15] While didactic education and/or passive dissemination of evidence-based guidelines have proven ineffective,[6] alternative methods (continuous educational strategies, alert systems, institutional audits) appear more effective, especially when combined.[16 17] Electronic systems that automatically remind physicians of the need for VTE prophylaxis have proven particularly useful,[17] however, in isolation, they do not promote the culture of patient safety and therefore, are unable to effectively ensure adherence to adequate VTE prophylaxis across an institution.

Surgical safety checklists have been associated with reduction of perioperative complications[18] as well as human errors.[19 20] As a result, these costless and effective verification tools are now considered a best practice in clinically high-risk areas[21 22] as they have revolutionised the way knowledge is translated into clinical practice.[22] The inclusion of VTE prophylaxis as part of our institutional preoperative surgical safety checklist made it imperative for the perioperative team to discuss a prophylactic regimen while still in the operating room thereby promoting communication and facilitating a multidisciplinary decision-making with regard to the most appropriate prophylactic modality (pharmacological and/or mechanical) that was tailored according to patients' risk stratification, and most importantly, ensuring adherence to prophylaxis within the first 24 hours postoperatively which ultimately resulted in less corrective measures required by the inpatient unit team.[21–23]

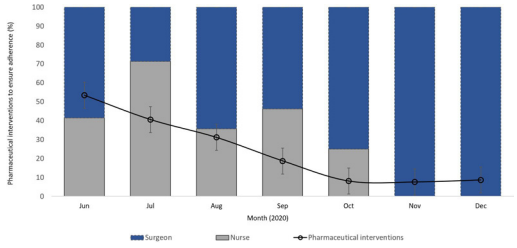

Figure 5 Interventions by clinical pharmacists to ensure adherence to adequate perioperative venous thromboembolism (VTE) prophylaxis after implementation of strategy (C) (June–December 2020). The black line represents the percentage (%) of patients requiring intervention by clinical pharmacists in relation to the total number of postoperative patients at high risk of developing perioperative VTE. The bars represent a monthly breakdown of whom (surgeon vs nurse) the interventions by clinical pharmacists were directed to.

Limitations of this work

This study has several limitations. First, the incidence of perioperative VTE (both during hospital admission as well as after hospital discharge) was not recorded such that the overall effectiveness of each strategy could not be compared with regard to this specific outcome. Nevertheless, the effectiveness of adequate perioperative VTE prophylaxis in reducing perioperative adverse events has already been well documented.[4 5] Second, the effectiveness of the various interventions implemented during strategy C could only be analysed as a bundle (but not individually). However, a single isolated intervention is unlikely to promote long-lasting clinical improvement when compared with a multidisciplinary team approach when it comes to tackling institutional processes and local cultural habits. Finally, the likely positive impact of an electronic alert system on the various strategies evaluated

during this 2-year historical series could not be assessed due to the manual nature of the institutional medical record during data collection.

CONCLUSIONS

In conclusion, among three strategies aimed at improving adherence to adequate perioperative VTE prophylaxis, the one based on a multidisciplinary team approach across multiple stages of patient care including (1) risk stratification on hospital admission, (2) an initial discussion regarding VTE prophylaxis including several key members of the healthcare team while still in the operating room, (3) confirmation/correction of risk stratification by a PACU nurse who also ensured that an appropriate prophylactic regimen had been prescribed, and (4) active engagement of clinical pharmacists in the postoperative period was significantly more effective than strategies based on corrective measures by a physician hospitalist (with or without a nurse) in the postoperative period.

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Contributors HdOL, LMdS and AdCVA led the overall design of the research and provided leadership for the study. LMdS and RF coordinated the development of the project. LMdS, SQS, GBM and AdCVA wrote the first draft of this manuscript which was approved by HdOL and AdCVA. AMPG, KKB, FNB, OM and LMdS contributed to the design of the research, acquired and analysed the data. GBM, AMHH and OM contributed to drafting of the manuscript; all authors revised it critically and approved the submission. All authors have approved the final version. LMdS is the author responsible for the overall content as the guarantor.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

Ethics approval This investigation was approved by the Institutional Research Ethics Committee (Protocol #4,488,741; CAAE: 40593320.6.0000.0087).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplemental information. Publishable contact details: qual idadeanestesiacma@gmail.com; leopoldo.muniz@saoluiz.com.br.

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