ORIGINAL

AUTOMATION AND IMPROVEMENT OF THROMBOEMBOLIC LOW MOLECULAR WEIGHT HEPARIN PROPHYLAXIS IN SURGERY WITH COMPUTERIZED DECISION SUPPORT IN A GENERAL HOSPITAL

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ABSTRACT

Introduction. The improvement of the surgical thromboembolic prophylaxis (STEP) rate after the introduction of an electronic tool to support surgeons in a general hospital is hereby described. The aim of this report is to analyze the effect of multidisciplinary support to the doctor with this computer tool to comply with the prophylactic low molecular weight heparin (LMWH) protocol in post-surgical patients and verify the potential decrease of VTE according to the published evidence.

Method. Surgical interventions carried out and analyzed from 2009 to 2021 were respectively 146,995 and 99,804. The program was designed in 2012 and was evaluated and improved in 2013. The program is fully implemented since 2014. The system includes the registration by the nurses of the risk factors of each patient who is going to be involved, through its assessment with the Caprini Scale for surgical thrombosis prophylaxis. The computer also informs the surgeon of the points obtained by the patient with that scale and offers prophylaxis with heparin low molecular weight (dose, onset depending on time surgery and frequency) if the patient is a candidate.

Results. Rates increased from 67% in 2009 to 82% in 2012 and 99.4% in 2021.

Conclusions. 1. The automation of the STEP produced an important improvement in compliance with the established protocol. 2. We estimate that 429 venous thromboembolism cases are avoided, in the period 2012-2021 according to the literature review carried out.

COMPLIANCE INDICATOR · LOW MOLECULAR WEIGHT HEPARIN · PROPHYLAXIS · SURGICAL – THROMBOEMBOLISM

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RESUMEN

Introducción. Se expone la mejora de la tasa de cumplimiento de la profilaxis tromboembólica quirúrgica (PTEQ) después de la implantación de un programa informático de apoyo en la toma de decisión de la misma, en los pacientes intervenidos en un hospital general El objetivo de esta publicación es analizar el efecto del apoyo multidisciplinar al cirujano con el programa informático para cumplir el protocolo de profilaxis con heparina de bajo peso molecular en pacientes postquirúrgicos y verificar la potencial disminución de la ETE postquirúrgica conforme a la evidencia publicada.

Método. Las intervenciones realizadas y analizadas de 2009 a 2021 fueron respectivamente 146.995 y 99.804. El programa se diseñó en el año 2012 y se evaluó y mejoró en el año 2013. Desde el año 2014 está completamente implantado. Las enfermeras registraron los factores de riesgo para cada paciente que va

a ser intervenido, mediante su evaluación por la escala Caprini para la PTEQ. El ordenador informa al cirujano de los puntos obtenidos por el paciente con esa escala y le propone, si el paciente es candidato a la misma, la profilaxis con heparina de bajo peso molecular (dosis, comienzo - según la hora de intervención - y frecuencia).

Resultados. La tasa pasó de un 67% en 2009 a un 82% en el año 2012, y hasta un 99,4% en el año 2021.

Conclusiones. 1. La automatización de la PTEQ produjo una importante mejora en el cumplimiento del protocolo establecido. 2. De acuerdo con la revisión bibliográfica realizada estimamos que se evitaron 429 casos de tromboembolismo venoso postquirúrgico en el periodo 2012-2021.

Indicador cumplimiento – Heparina de bajo peso molecular - Profilaxis - Postquirúrgico - Tromboembolismo

INTRODUCTION

Venous thromboembolism (VTE) is a complex pathology, influenced by numerous factors that frequently occurs in hospitalized patients at risk. Correct thromboprophylaxis has been underused, which exposes the patient to the appearance of deep vein thrombosis or pulmonary thromboembolism (PE).[1]

In Europe have been published 260,000 fatal episodes of VTE, acquired in hospitals in 2007, together with 108,535 deaths produced at the outpatient level.[2] A study from the UK, which included 947,454 middle-aged women, from National Health Service admissions, recorded that 239,614 had undergone surgery and of these 5,914 (2.46%) had to be readmitted with VTE, including 270 deaths (0.11%). Episodes were documented up to 12 weeks after the intervention. Patients who had undergone surgery were 70 times more likely to be readmitted than those who had no surgery.[3]

Surgical thromboembolic prophylaxis (STEP) should be established following the recommendations of expert groups but also based on the individual evaluation of each patient before a specific surgical procedure.[4] Thus, patients with an indication for hospitalization [5] that include implantation of joint prostheses or abdominal, urological, gynecological, neurological or cardiovascular surgery have the greatest determinant of thromboembolic risk. However, there are other patients with multiple comorbidities, a history of thromboembolic disease (TEE), morbid obesity, chronic obstructive pulmonary disease or advanced cancer who are at high risk of VTE and only individual clinical evaluation will detect them as candidates for prophylaxis.[6]

Kucher, et al.[7] applied a model for the evaluation of individual patients that assigned scores according to the weight of each risk factor. It assigned 3 points to the factors of cancer, thrombophilia or history of TE; 2 points for major surgery and 1 point for immobility, advanced age, hormones, or obesity. A score of 4 or more was considered a high-risk patient for prophylaxis. From a group of 250 patients with a high-risk score, they randomly took two groups. In the control group, which did not receive electronic alerts, only 1.5% of patients received mechanical prophylaxis and 13% received pharmacological prophylaxis and had a 90-day incidence of VTE of 8.2%. In the second group, which received electronic alerts, the two types of prophylaxis reached 10% and 26%, respectively, and the incidence of VTE was reduced to 4.9% ($p < 0.001$).

Caprini, et al.[4, 5] developed the VTE risk scoring system, which bears his name, by researching the relative probability of associating VTE with each of the risk factors in the scientific literature. They were classified into four levels: low risk (1), moderate risk (2), high risk (3, 4) or very high risk (>4). Prophylaxis recommendations were related to each group. This scoring system was adopted by the American College of Chest Physicians and translated into 12 languages, although this institution later considered it too complex, difficult to perform without being computerized, and lacking prospective validation.[8, 9] This scale has been considered valid in patients with medical pathologies, in Vascular Surgery by the American Venous Forum [8] in Plastic Surgery [9] in hospitalized patients. It identifies patients with medical pathologies at risk of developing VTE and surgical patients who require STEP individually, when there is no available data from clinical trials in the scientific literature, for a group of patients or for a particular patient. Previously [7] had already recommended strategies to improve the PTE.

Due to the serious risk of VTE in surgical patients, it is highly recommended that hospitals have the STEP compliance indicator monitored, to avoid VTE and thus improve patient safety.

The aim of this report is to analyze the effect of multidisciplinary support to the doctor with this computer tool to comply with the prophylactic low molecular weight heparin (LMWH) protocol in post-surgical patients and verify the potential decrease of VTE according to the published evidence.

METHOD

This retrospective study has been carried out at the Hospital de Barcelona, a general hospital for acute patients with 270 beds, open to 1,100 doctors from 36 specialties.

From 2004 to 2011, an annual indicator of STEP compliance had been obtained in a representative sample of surgical interventions. The evolution of this annual indi-

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POSTOPERATIVE THROMBOEMBOLIC RISC

Patient: ..... Clinical history/Case: .....
Age: ..... Sex: ..... Location: .....
Operation: ..... Reservation: .....

The following patients are excluded from the prescription of profilaxis:

- Under 40 years of age with surgical reserve time of less than 60 minutes.
- With administration of platelet-rich plasma (PRP), ambulatory hand or foot surgery, ambulatory breast surgery, maxillofacial surgery, phimosis, hysteroscopy, anesthesia infiltrations, ophthalmology interventions, ambulatory dermatological surgery, ambulatory urological surgery, hip puncture or rhizolysis, proctology.
- Less than 4 points in the scale risk.

The points **E, H, P** will be indicated in the computer.

The points **L, M, N** and **W** will be filled in by the operating room nurses. The rest for those on the floor before going to the operating room.

The data of obesity (BMI >30) will be incorporated as a risk factor automatically once the current weight and height have been entered.

Factor scoring

Age factors:

- ☐ 3-Age over 75 years
- ☐ 2-Age between 61 and 64 years
- ☐ 1-Age between 40 and 60 years

Surgical factors:

- ☐ 4-Lower extremity orthopedic surgery (elective)
- ☐ 4-Fracture of the pelvis, hip or lower extremity
- ☐ 4-Polytrauma
- ☐ 2-Arthroscopic surgery
- ☐ 2-Open or laparoscopic surgery lasting more than 60 minutes
- ☐ 1-Ambulatory or short stay surgery

Personal risk factors:

- ☐ 3-History of thrombosis (AMI, brain...) or personal or hereditary pulmonary embolism
- ☐ 2-Active cancer under treatment
- ☐ 2-Forecast immobilization in bed for more than 72 hours ** In surgery room
- ☐ 2-Forecast immobilization with plaster more than a month ** In surgery room
- ☐ 2-Central venous catheter ** In surgery room
- ☐ 1-History of recent major surgery (less than a month)
- ☐ 1-Have varicose veins
- ☐ 1-Ulcerative colitis or Chron's disease
- ☐ 1-Obesity (BMI >30)
- ☐ 1-Chronic respiratory or cardiac disease
- ☐ 1-Sepsis ** In surgery room
- ☐ 1-Treatment with oral contraceptives or hormone replacement therapy

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FIG. 1. Surgical patient thromboembolism risk assessment sheet.

cator was made known to the doctors and the Hospital Management, without taking more active measures.

In 2012, a working group comprised Hematology, Pharmacy, IT, Nursing and Operating Room Departments. This group designed a computer program to significantly improve the STEP compliance indicator. The indicator was defined as the percentage of surgical patients who had received pharmacological STEP

TABLE 1. Start and final time of the surgical intervention and schedule in the dose computer of LMWH according to the duration of the intervention.

	*Surgery duration ≤120 min**			*Surgery duration >120 min**			
Start	*End*	*+6 hours*	*+ 12 hours*	*End*	*+6 hours*	*+ 12 hours*	*Proposal*
8:00	10:00	16:00	22:00	12:00	18:00	0:00	20:00 hours*
9:00	11:00	17:00	23:00	13:00	19:00	1:00	
10:00	12:00	18:00	0:00	14:00	20:00	2:00	
11:00	13:00	19:00	1:00	15:00	21:00	3:00	
12:00	14:00	20:00	2:00	16:00	22:00	4:00	
13:00	15:00	21:00	3:00	17:00	23:00	5:00	24:00 hours**
14:00	16:00	22:00	4:00	18:00	0:00	6:00	
15:00	17:00	23:00	5:00	19:00	1:00	7:00	
16:00	18:00	0:00	6:00	20:00	2:00	8:00	
17:00	19:00	1:00	7:00	21:00	3:00	9:00	06:00 hours***
18:00	20:00	2:00	8:00	22:00	4:00	10:00	
19:00	21:00	3:00	9:00	23:00	5:00	11:00	
20:00	22:00	4:00	10:00	0:00	6:00	12:00	
21:00	23:00	5:00	11:00	1:00	7:00	13:00	
22:00	0:00	6:00	12:00	2:00	8:00	14:00	12:00 hours****
23:00	1:00	7:00	13:00	3:00	9:00	15:00	
0:00	2:00	8:00	14:00	4:00	10:00	16:00	

*: First dose complete and second dose 16 hours after.
**: a) If 5,000 UI: First and second doses as a half dose, at those two times and after 12 hours. Followed by full doses every 24 hours. If 2,500 UI with CrCl < 50 ml/min or serum Cr >1,5 mg/dl: first dose at 24 h day 1, second dose at 18 h day 2 and thrird dose at 12:00 h day 3 and followers; b) Half dose for first and second doses at this time and 12 hours. Followed by full doses every 24 hours.
***: Full first and second dose after 30 hours.
**** Full first and second dose after 24 hours.

over the total number of patients with an indication for it. The prescription of LMWH, the time and duration of its administration in the hospital and whether the dose was correct, as well as the patient's risk factors, were analyzed for each patient.

The workgroup designed the risk factor collection sheet (Fig. 1) that the nurses filled out and recorded in the hospital's central computer. The collection sheet includes 19 risk factors for post-surgical TEE. Four of these factors (L, M, N and W of the chart) are collected and recorded in the surgical area by experienced nurses and the rest of the factors by the nurses of the hospitalization unit when the patient is admitted.

The program calculates the patient's score to receive LMWH or not. The work circuit for collecting TEE risk factors from the patient and the prescription of LMWH by the surgeon is as follows:

a. Patient entry.
b. The nurses review and record in the computer the 17 risk factors on the collection sheet (four risk factors for the operating room nurses and 13 for the ward nurses).
c. The computer calculates the score according to the Caprini scale.[4]
d. The surgeon sees the LMW heparin prescription proposal, adapted to the time of the intervention and the patient's kidney function, and prescribes it or not.

The Hematology and Pharmacy Departments designed the systems for calculating the hours to administer LMWH for the computer program: One for interventions lasting less than or equal to 120 minutes and another for interventions lasting greater than 120 minutes. They were included in the computer program for the design of the automated electronic prescription that the surgeon must confirm. If the score obtained with the risk factors is less than four points, the program does not offer the surgeon the prescription of LMWH. If it is equal to or greater than four points, the program offers the surgeon the prescription of LMWH according to the end time of the intervention, the frequency of administration, and the dose according to what is stated in Table 1.

The LMWH used were from 2009 to 2014 dalteparin (Fragmin®) at a dose of 2,500 or 5,000 IU depending on the patient's risk. Between 2015 and 2021, bemiparin (Hibor®) in doses of 2,500 or 3,500 IU depending on the patient's risk.

The patients who were excluded from the prescription of thromboembolic prophylaxis were the following:

- <40 years old and surgical reserve time up to 60 minutes
- With platelet-rich plasma administration
- Outpatient hand or foot surgery
- Outpatient breast surgery

TABLE 2. Surgical interventions classified by specialty carried out with surgical thromboprophylaxis and surgery excluded from prophylactic LMWH.

Surgical interventions	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*Total*	*%*
Orthopedics and traumatology	3,502	3,678	4,026	4,170	3,161	3,186	3,077	3,247	2,598	2,903	33,548	34.7
General and digestive surgery	2,302	2,205	2,259	2,190	2,177	2,141	2,150	2,137	1,746	1,922	21,229	22
Urology	1,037	1,046	976	933	1,026	1,047	1,085	1,188	1,014	1,220	10,572	10.9
Gynecology	1,136	1,072	990	944	880	917	883	891	730	817	9,260	9.6
Plastic and restorative surgery	543	584	496	443	417	476	534	610	429	464	4,996	5.2
Maxillofacial surgery	120	147	135	123	121	112	166	159	124	143	1,350	1.4
Neurosurgery	359	412	402	378	375	349	420	509	474	440	4,118	4.3
Otolaringology	442	461	481	534	463	473	432	417	311	375	4,389	4.5
Vascular surgery	411	419	416	422	415	400	431	415	281	347	3,957	4.1
Cardiovascular surgery	201	208	225	191	200	192	151	124	142	151	1,785	1.8
Thoracic surgery	184	142	152	159	145	133	163	142	145	138	1,503	1.6
Total	10,237	10,374	10,558	10,487	9,380	9,426	9,492	9,839	7,994	8,920	96,707	100
Surgical interventions excluded from prophylactic LMWH	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*Total*	
Anesthesia	1,064	1,066	1,181	1,140	1,054	1,113	1,119	1182	902	1,202	11,023	
Ophthalmology	3,516	3,643	3,556	3,592	3,531	3,353	3,548	3555	2,958	3,653	34,905	
Dermatology	2	0	3	32	32	58	59	112	110	147	555	
Pediatric surgery	306	280	276	300	258	243	207	182	138	108	2,298	
Total	14,819	15,083	15,298	15,551	15,604	15,213	14,425	14,870	12,102	14,030	146,995	

TABLE 3. Surgical interventions with automated prophylaxis 2012-2021 and estimation of avoided VTE cases.

Medical specialty	*No.*	*VTE rate postsurgery (%)*			*VTE cases avoided*	*Reference with STEP*	*Reference without STEP*
		without STEP	*with STEP*	*Decrease*			
Orthopedics and traumatology	33,548	1	0.17	0.83	278	Haut, et al. 2012 [17]	Haut, et al. 2012 [17]
General and digestive surgery	21,229	2.2	1.3	0.9	191	Nelson, et al. 2015 [18]	Nair, et al. 2021 [19]
Urology endoscopic surgery	6,449	0.55	0.45	0.1	6	Rice, et al. 2010 [20]	Rice, et al. 2010 [20]
Urology open surgery	4,123	21	7	14	577	Kukreja, et al. 2015 [21]	Kukreja, et al. 2015 [21]
Gynecology	9,260	6.67	2.7	3.97	368	Corr, et al. 2015 [22]	Corr, et al. 2015 [22]
Plastic and restorative surgery	4,996	1.69	0.02	1.67	83	Pannucci, et al. 2011 [23]	Keyes, et al. 2018 [24]
Maxillofacial surgery	1,350	0.40	0.40	0	0	Lodders, et al. 2015 [25]	Zhou, et al. 2019 [26]
Neurosurgery	4,118	11.4	5.7	5.7	235	Macki, et al. 2019 [27]	Khan, et al. 2018 [28]
Otolaringology	4,389	0.5	0.08	0.42	18	Cramer, et al. 2018 [29]	Garritano, et al. 2013 [30]
Vascular surgery	3,957	10.2	1.4	8.8	348	Ramanan, et al. 2013 [31]	Sutzko, et al. 2018 [32]
Cardiovascular surgery	1,785	2.1	1.1	1	18	Passaglia, et al. 2015 [33]	Passaglia, et al. 2015 [33]
Thoracic surgery	1,503	7.3	3.1	4.2	63	Sterbling, et al. 2018 [34]	Sterbling, et al. 2018 [34]
Total	96,707				2,185		
Improvement prophylaxis 22% (from 77-99%)			VTE avoided:		481		

VTE: Venous thromboembolism; STEP: Surgical thromboembolism prophylaxis.

- Outpatient dermatological surgery
- Outpatient urological surgery
- Maxillofacial surgery
- Phimosis
- Infiltrations of anesthesia
- Ophthalmology interventions
- Hip puncture
- Rhizolysis
- Proctology
- Less than 4 points on the risk Caprini scale

The results were reported to the personnel involved (doctors, nurses, and pharmacists) and to the Hospital Management on an annual basis.

RESULTS

Table 2 details the surgical activity of the hospital from 2012 to 2021 by specialty. Fig. 1 shows a graph showing the evolution of the annual STEP compliance indicator from 2009 to 2021.

Table 3 shows the number of operated patients who

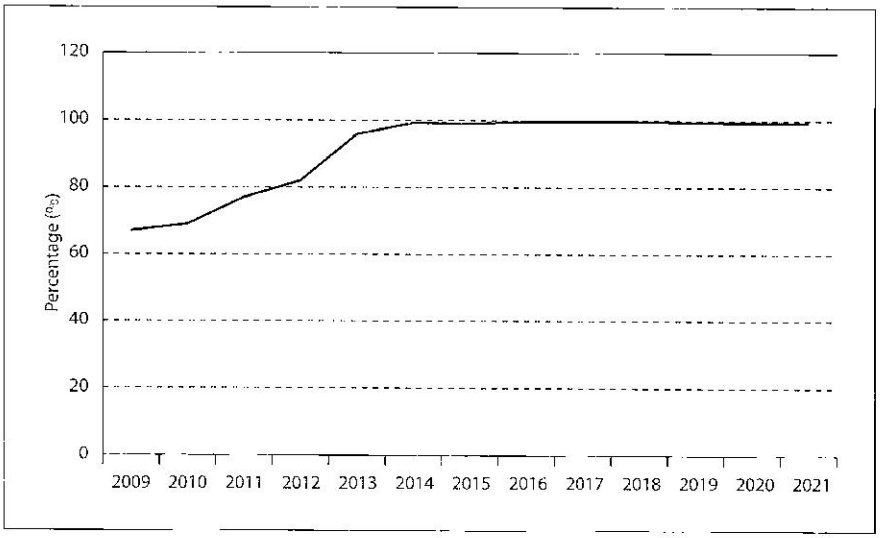


FIG. 2. Compliance indicator surgical thromboembolic prophylaxis 2009-2012.

received heparin STEP from 2012 to 2021 according to the computerized protocol, and the cases of VTE avoided according to the literature reviewed for each of the 11 surgical specialties with an indication for STEP.

DISCUSSION

As can be seen in Fig. 2, our initial more passive strategy, although with a positive evolution, did not allow reaching 69% compliance until 2010. That year, given that the omission of pharmacological STEP still affected 1,598 patients, the insufficient application of STEP was disseminated with greater insistence and in 2011 a compliance rate of 77% was achieved.

In 2012, the year in which the STEP automation was partially implemented, compliance improved up to 82% to obtain, the following years, (STEP automation for all the interventions in which it was indicated) values greater than 99 %, which was the objective of our program.

Our results are similar to those of Tooher, et al.,[10] who indicated that more passive strategies, such as posters or educational actions, had been relatively ineffective in improving compliance levels. In another study,[11] alerts were generated on the computer that helped to investigate the omissions of the PTEQ but left periods of time at risk of TEE.

Lesseroth, et al.[12] reported an experience similar to ours, applying a computer program to support the surgeon's prescription in STEP. The percentages of use of a computerized STEP protocol in General Surgery, Neurosurgery, and Orthopedic and Trauma Surgery improved in a year and a half from 10%, 20%, 35% and 25% to 85%, 100%, 100% and 97% respectively, results similar to those of this study.

We applied the decrease in the VTE rate obtained in specific publications [11, 13-28] to the 11 surgical specialties that had an indication for STEP in our center (Table 3), we estimated that 481 cases of postsurgical VTE had been avoided since the year 2012 to the year 2021.

Some of the limitations of this study are: It is a retrospective analysis, without subgroup analysis and the prevented cases of VTE are estimated.

Based on these results, we believe that the automation of STEP can be useful in other hospitals to reduce the risk of patients suffering from postsurgical VTE cases, which in some cases (0.2-0.9%) can be fatal. CP

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