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Review of a diagnostic pathway for patients with suspected deep venous thrombosis in a Norwegian ED

Graduate thesis in Medicine, Programme of Professional Study

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Abstract

Introduction

Deep venous thrombosis (DVT) is a condition with high incidence in the Western world. The lack of a standardized pathway for patients with suspected DVT in Norway has led to unnecessary referral of patients to the Emergency Department (ED). St. Olav's Hospital in Trondheim, Norway, implemented a diagnostic pathway in May 2019. In this new pathway, a hotline for consulting was established between the General practitioners and an experienced emergency physician in the ED. If suspicion of DVT, the patients were examined the following day with ultrasound by an experienced ED physician, and not by a radiologist as during conventional work-up. The aim of this study was to investigate the impact of the diagnostic pathway on the ED length of stay (LOS), patient influx, and ED crowding.

Methods

The retrospective data were collected from a database (Acute ED Database) and included initially all patients with suspected diagnosis of DVT between 1 January 2018 to 31 December 2019 at St. Olav's Hospital (n=2415). A randomized selection of 300 patients was performed to investigate multiple variables in two patient groups before (n=150) and after (n=150) implementation of the new diagnostic pathway. Information on clinical data including DVT risk stratification tools (Wells score), D-dimer, comorbidity, complications, risk factors, medical treatment, and follow-up appointments was collected manually from electronic patient records (EPR).

Result

Overall, the frequency of ED visits for the patient population increased with 26% from 2018 to 2019 and the frequency of diagnosed DVT patients were similar before and after implantation of the new diagnostic pathway. A total of 13 (8.7%) patients were diagnosed with DVT in 2018 and 19 (12.7%) patients in 2019, $p=0.26$. LOS was significantly reduced with 23%, ($p<0.0001$) and patient influx was steered towards before noon. More patients included in the pathway were discharged from the ED (23.3%), but there was an increase in patients returning to the ED for scheduled follow-up (13.3%, $p<0.05$). The rate of complications (0.7%) and mortality (0.7%) did not increase after implantation of the new diagnostic pathway.

Conclusion

The implementation of a new diagnostic pathway within the ED led by emergency physicians decreased the LOS for patients with suspected DVT and less ED crowding in general. The patient influx was shifted towards less resource demanding periods in the ED and the diagnostic pathway appeared safe and efficient.

Introduction

Venous thromboembolism (VTE) is a collective term for deep venous thrombosis (DVT) and pulmonary embolism (PE). It is a condition where blood clots create a thrombus in the venous system, which may be dislodged and create an embolus that travels in the venous system.^{1,2} Worldwide the incidence of VTE is approximately 10 million every year, and it is the third most common vascular incident after myocardial infarction (MI) and cerebral stroke.³ The incidence of DVT in Europe has recently been reported as 70–149 cases/100.000 person-years.⁴ Due to increased life span in the western world, and thereby also increased prevalence of risk factors such as heart failure, obesity and cancer, there is a higher incidence of VTE in the elderly population.⁵⁻¹⁰ The vast majority of patients with suspected DVT is diagnosed and treated in the emergency department.⁴

The lack of a standardized diagnostic pathway for patients with suspected DVT in Norway has led to unnecessary referral of patients to the Emergency Department (ED). Patients with possible DVT have generally been considered as low acuity level patients by arrival in the ED, which results in prolonged ED length of stay (LOS) because more urgent conditions are prioritized. Crowded EDs is a major challenge, both in Norway and globally. It has been suggested that the influx of patients with suspected DVT to the health care system and EDs will increase in the near future, and thereby the need of a more efficient diagnostic pathway for this patient group is paramount.^{8,11,12}

In May 2019, St. Olav's University Hospital established a new diagnostic pathway for patients with suspected DVT. This pathway allows general practitioners (GPs) to contact the experienced emergency physician directly by phone and schedule an appointment for the patient, typically the following day. By arrival to the ED the following day, the patients with suspected DVT are examined by the emergency physician with ultrasound and not by the radiologist as in the traditional work-up. The overall goal for this new diagnostic pathway was to redirect ED influx of DVT patients from evening and night to the morning hours, which has shown to have less crowding and resource demanding patients. We hypothesized that this new diagnostic pathway would lead to decreased ED LOS and improved work-up efficiency for this patient group.

The main aim of this study was to describe the patient population referred to the ED at St. Olav's Hospital with suspected DVT before and after implementation of a new ED diagnostic pathway. We wanted to investigate whether the new diagnostic pathway influenced the time of arrival, ED length of stay and ED crowding.

Study Setting

Triage system

All patients referred to the ED at St. Olav's University Hospital are assigned a level of priority or presumed acuity at arrival using the triage system "Rapid Emergency Triage and Treatment system" (RETTS©, Predicare AB, Göteborg, Sweden). RETTS is based on vital signs and different chief complaints (Emergency Symptoms and Signs, ESS) when the patient is assigned a priority level, while laboratory values are not included in the primary triage decision.¹⁴ RETTS is a five-level system ranging from Blue to Red, the latter being the highest (most severe) priority level.¹⁵

Diagnostic pathway

In the traditional work-up of suspected DVT, patients were directly referred from the GPs to the radiologist department for ultrasonographic examination, without involving the emergency physicians. If negative diagnostics the patient were discharged directly home from the radiology service, while if a DVT was detected the patient was referred to the ED. This led to an unpredictable influx of patients and in turn this patient group often ended up with long waiting times in the ED. With the new diagnostic pathway, a hot-line was established where the GPs could call an experienced Emergency physician for consulting. An appointment is then scheduled, often the next day in the morning. The GP may start the patient on anticoagulation therapy in anticipation of the appointment in the ED if high suspicion for DVT. The patients then meet as scheduled in the ED where a clinical- and ultrasound examination were performed by the emergency physician. Further management of the patient is decided based on the findings in the ED (figure 1).

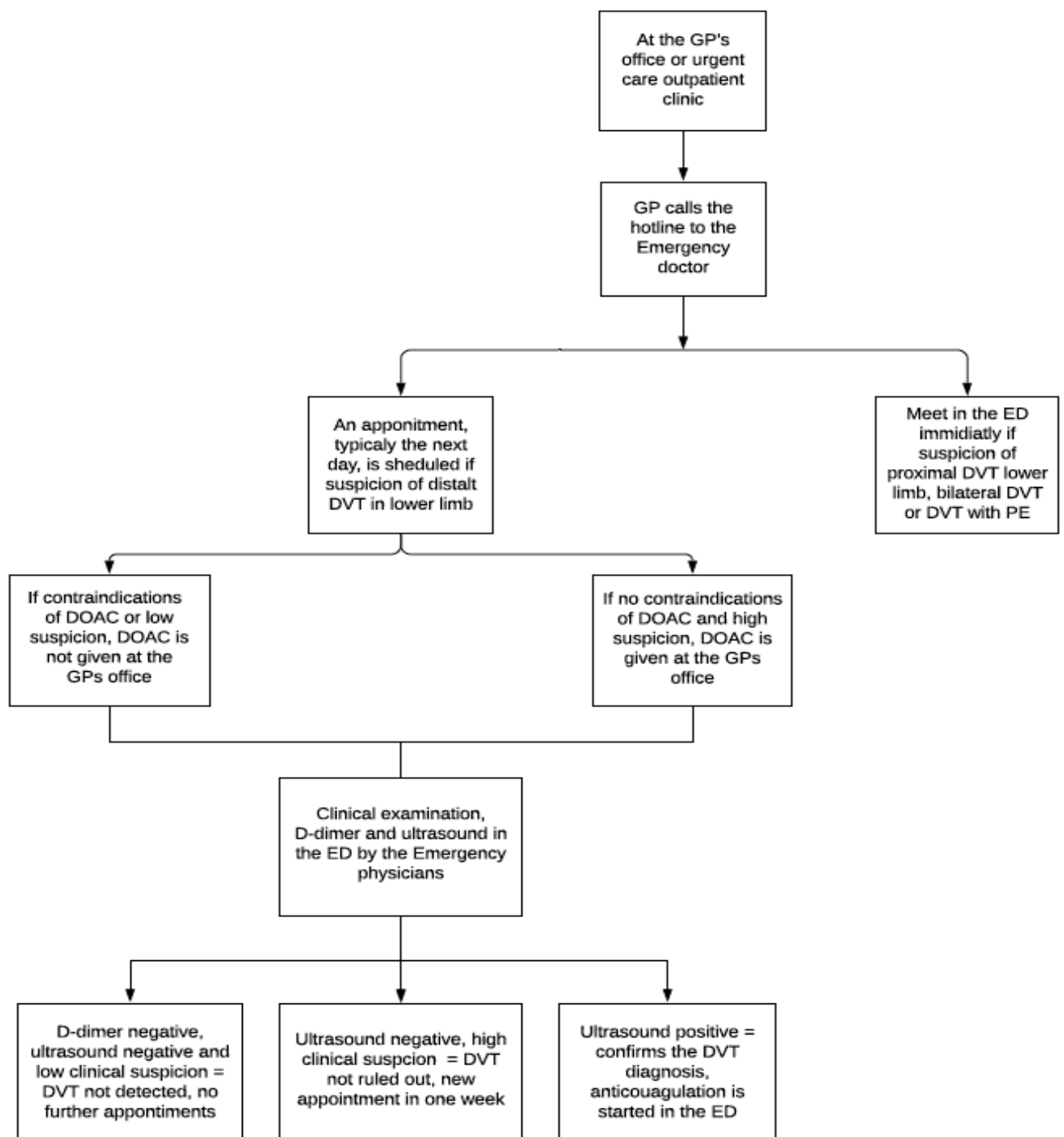


Figure 1: Steps of the diagnostic pathway

Methods

Clinical Setting

St. Olav's Hospital is located in Trondheim, Central Norway. In 2018, the hospital was the regional hospital for 720.000 inhabitants and the local hospital for 320.000 of these inhabitants in the Trondheim region.¹³ The ED at St. Olav's Hospital has more than 24.000 ED visits annually. The patients are mostly older than 16 years of age and nearly 50% of the patients are > 65 years of age. Patients having problems related to gynecology/obstetrics, ENT, and ophthalmology are seen at separate Eds, or outpatient clinics within the hospital.¹¹ The ED has specialists in Emergency Medicine who are, in addition to clinical work, responsible for patient logistics and resource management in the ED.

Patient data

The study is a descriptive retrospective study based on patient data gathered at the ED of St. Olav's University Hospital between January 1, 2018 and December 31, 2019. The data was collected from the local logistical software Acute ED Database (AAD, Version 1.5.5. Copyright © Helse Vest IKT, Bergen, Norway) and from the patient administration system (PAS, Hemit, 1986, version 5.2, Norway).

Study population

We identified patients with suspected DVT based on the following criteria (figure 2):

- 1) Patients triaged with RETTS ESS 15 (pain in limb, swelling in limb, problems in extremity),
- 2) Search in the Acute ED database commentary field for the specific keywords DVT, thromboembolism, thrombus, swelling in lower extremity/leg/foot, and;
- 3) Patients that both had RETTS ESS 15 and keyword found in commentary field.

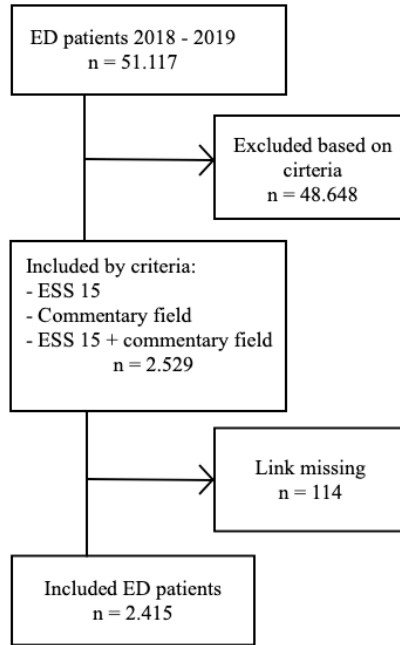


Figure 2: Flowchart included patient

The population (n=2.415) is further divided into two smaller populations. The diagnostic pathway was implemented May 1, 2019 and therefore the populations for comparison is chosen for the latter half of 2018 and 2019, respectively.

Demographical data (age and gender) and clinical variables (priority code, length of stay (LOS) in ED, time of arrival, level of care, and discharge diagnosis) were collected from the Acute ED Database. We manually collected other clinical data of interest (including Wells score, the level of D-dimer, risk factors for DVT, comorbidity, complications such as PE, mortality, location of DVT based on compression ultrasound, and anticoagulation treatment) from electronic patient data (DocuLive) and radiology journal system (Sectra IDS7).

Variables of interest is explained and defined as follows. Wells score is a tool for clinical pre-test probability of DVT.¹⁶ Risk factors for DVT are defined as use of estrogen medicine, immobilization, surgery, trauma, pregnancy, puerperium, cancer and lupus anticoagulant, missing antitrombin III-, protein C- and protein S, factor V Leiden mutation, missing prothrombin 2021A, high concentration of factor VIII and hyperhomocysteinemia. Comorbidity is defined as cardiovascular- and/or lung diseases.

Statistical analysis

The results were reported as number, percentages of the median (Md) and interquartile range (IQR). Variables of interest were compared using the Chi-quadrant test for categorical variables and the Mann-Whitney *U* test for continuous variables. A *p*-value of <0,05 was considered as statically significant. Data was exported and analyzed using Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) and IBM SPSS Statistics v. 26 (IBM Corporation, Armonk, NY, USA).

Ethics

The study is a part of the continuing quality improvement performed in the Emergency Department at St. Olav's Hospital, Trondheim, Norway. The Regional Committee for Medical and Health Research Ethics (REK) and the Data Protection Officer at St. Olav's Hospital have approved the study (ESA, 16/9114).

Results

Study population

A total of 51.117 patients were referred to the ED at St. Olav's Hospital between 2018 and 2019, and of these 2.529 (4.9%) patients with suspected DVT are included in our study based on inclusion criteria (figure 2). For 114 of these patients no link to the patient administration system (PAS) is found and they are thus excluded from the study. Thus, the final number of patients included is n=2.415. From 2018 to 2019 there is an increase in patients referred to the ED with suspected DVT from 1.117 to 1.412 (26%). Next, the population is randomly divided into two populations using the statistical program SPSS, n=150 before and after the implementation of the diagnostic pathway. Population 2018 (n=150) is from 1th of July to 31th of December 2018 and population 2019 (n=150) is from 1th of July to 31th of December 2019 (figure 3).

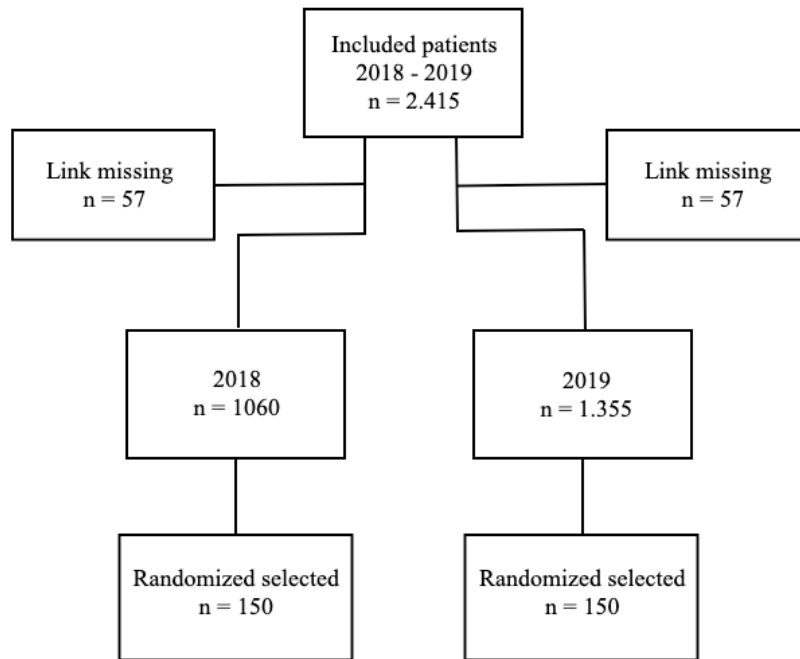


Figure 3: Final number of included patients in the two time-periods.

Baseline characteristics

Table 3 displays characteristics of the study population according to the time-periods 2018 and 2019, i.e. before and after the implementation of the diagnostic pathway. Of the total population (n=300), 32 (10.6 %) patients were diagnosed with DVT, 13 (8.7%) of these in 2018 and 19 (12.7%) in 2019. There is no significant difference between the groups before and after implementation of the diagnostic pathway, $p=0.26$. The distribution of age and gender is similar in the two time- periods. All the patients received a triage upon ED arrival. In general, the patients have a lower triage code in 2019 than 2018. For both years yellow is the triage code of highest frequency.

Table 3: Characteristics at baseline before and after implementation of the diagnostic pathway			
	2018 n = 150	2019 n = 150	p-value
Diagnoses			0.26
DVT, n (%)	13 (8.7)	19 (12.7)	
Not DVT, n(%)	137 (91.3)	131 (87.3)	
Gender			0.82
Male, n(%)	79 (52.7)	77 (51.3)	
Female, n(%)	71 (47.3)	73 (48.7)	

Table 3: Characteristics at baseline before and after implementation of the diagnostic pathway			
Age, median (IQR)	69 (53 – 79.3)	70 (52.5 – 78.3)	0.85
Gender			0.82
Male, n(%)	79 (52.7)	77 (51.3)	
Female, n(%)	71 (47.3)	73 (48.7)	
Comorbidity			1.00
Yes, n(%)	72 (48.0)	72 (48.0)	
No, n(%)	78 (52.0)	78 (52.0)	
Triage code			0.04
Red, n(%)	4 (2.7)	1 (0.7)	
Orange, n(%)	16 (10.7)	18 (12.0)	
Yellow, n(%)	111 (74.0)	116 (77.3)	
Green, n(%)	6 (4.0)	12 (8.0)	
Blue, n(%)	13 (8.7)	3 (2.0)	
Number of risk Factors			0.61
0, n(%)	79 (52.7)	86 (57.3)	
1, n(%)	65 (43.3)	58 (38.0)	
2, n(%)	6 (4.0)	6 (4.0)	
3, n(%)	0 (0.0)	1 (0.7)	
Wells Score			0.20
High probability, n(%)	58 (38.2)	44 (29.3)	
Moderate probability, n(%)	23 (15.3)	29 (19.4)	
Low probability, n(%)	69 (46)	106 (51.3)	
D-dimer			0.23
Measured, n(%)	104 (69.3)	99 (66.0)	
Not measured, n(%)	46 (30.7)	51 (34.0)	
PE complication			1.00
Yes, n(%)	1 (0.7)	1 (0.7)	
No, n(%)	149 (99.3)	149 (99.3)	
Level of Care			<0.0001
Outpatient clinic, n(%)	66 (44.0)	101 (67.3)	
Admitted to the ward, n(%)	84 (56.0)	49 (32.7)	
Control appointment			0.0002
Yes, n(%)	16 (10.7)	36 (24.0)	
No, n(%)	134 (89.3)	114 (76.0)	
State at discharge			1.00
Alive, n(%)	149 (99.3)	149 (99.3)	
Dead, n(%)	1 (0.7)	1 (0.7)	

In both time-periods patients have the same level of comorbidity and number of risk factors for VTE. Moreover, classification of the patients according to the Wells score and the use of D-dimer is similar in the two groups. PE as a complication of DVT is a rare event (0.7%) and

not different in 2018 and 2019. In 2019 more patients are discharged from the ED (67.3%) than in 2018 where more patients are admitted to the ward (56.0%), $p<0.05$. Number of patients returning for a scheduled appointment increased from 2018 (10.7%) to 2019 (24.0%), $p<0.05$. Common to all these patients were that none ($n=52$) of them were diagnosed with DVT at the first meeting. The short-term mortality rate is low for this patient group as only 0.7% of the patients in both groups died during hospital-stay.

In table 4 the most frequent discharge diagnosis is presented, $n=300$. For both time-periods all of them are known to be typical differential diagnosis to DVT. There is no significant difference between the populations comparing all diagnosis, $p=0.135$.

Table 4: Most frequent discharge diagnosis, ICD-10 diagnosis 27		
Diagnoses	2018 n=150	2019 n=150
R22.4 Localized swelling, mass and lump, lower limb, n(%)	27 (18.0%)	22 (14.7%)
M79.6 Pain in limb, n(%)	7 (4.7%)	20 (13.3%)
I80.2 Phlebitis and thrombophlebitis of other deep vessels of lower extremities, n(%)	9 (6.0%)	19 (12.7%)
A46 Erysipelas, n(%)	8 (5.3%)	3 (2.0%)
I80.0 Phlebitis and thrombophlebitis of superficial vessels of lower extremities, n(%)	4 (2.7%)	5 (3.3%)
I80.1 Phlebitis and thrombophlebitis of femoral vein, n(%)	4 (2.7%)	0 (0.0%)
I74.3 Embolism and thrombosis of arteries of lower extremities, n(%)	2 (1.3%)	5 (3.3%)
I70.2 Atherosclerosis of arteries of extremities, n(%)	3 (2.0%)	3 (2.0%)
M66.0 Rupture of popliteal cyst, n(%)	3 (2.0%)	3 (2.0%)

Logistical features

Table 5 presents the logistical features of the patients with suspected DVT according to the time-periods in 2018 and 2019. After implementation of the diagnostic pathway, LOS is significantly reduced, $p<0.05$. At the same time one were able to shift time of influx to before noon compared to the traditional pathway, $p<0.05$. The distribution of day of input is similar in the two time-periods.

Table 5: Logistical features			
	2018 n=150	2019 n=150	p-value
Median time in ED, hours and minutes (IQR)	3:47 (2:18-5:42)	2:33 (1:43-4:04)	<0.001

Table 5: Logistical features			
Day of input			0.70
Monday, n(%)	32 (21.3%)	32 (21.3%)	
Tuesday, n(%)	20 (13.3%)	22 (14.7%)	
Wednesday, n(%)	17 (11.3%)	23 (15.3%)	
Thursday, n(%)	32 (21.3%)	26 (17.3%)	
Friday, n(%)	30 (6.7%)	34 (22.7%)	
Saturday, n(%)	10 (6.7%)	9 (6.0%)	
Sunday, n(%)	9 (6.0%)	4 (2.7%)	
Time of day for Admission ^a			<0.001
0.01-06.00, n(%)	1 (0.7%)	5 (3.4%)	
06.01-12.00, n(%)	62 (41.3%)	89 (59.7%)	
12.01-18.00, n(%)	69 (46.0%)	49 (32.9%)	
18.01-24.00, n(%)	18 (12.0%)	6 (5.0%)	
^a Missing data for 1 patient			

Discussion

The study has given a descriptive overview of patients presenting with suspected DVT to the ED at St. Olav's Hospital between the latter half of 2018 and 2019, before and after the diagnostic pathway was implemented. The patient population in this study constitute 4.8% of the total ED population in the study period. The Norwegian health care system has a special function with GPs as the intended "gate keepers" of patient referral to the ED. Based on this, it is predictable that the number of patients visiting the ED should be as low or lower than in international studies. Despite this, compared to international studies the number of patients included in this study is higher, 0.5-1.0%.^{4,18} A possible explanation to this can be that ESS 15 include a wide specter of possible diagnosis. This can lead to an overestimation of the real number of patients with suspected DVT. Despite a higher number of patients in our study, age- and gender distribution correlate well with similar studies.¹⁸⁻²⁰

The number of referred patients increases with 26% between the two time-periods. An explanation to this can be that in the traditional system patients met directly to the radiologist department for ultrasound examination instead of in the ED. If the ultrasound was negative, they were not referred to the ED, but discharged home. With the diagnostic pathway, all the patients meet directly in the ED, hence the total number of patients in the ED increases.

With the diagnostic pathway, the number of patients who got a DVT diagnosis increased from 13 in 2018 to 19 in 2019. The finding is not significant but might show a trend towards better

diagnostic. There can be several explanations to this. First, increased focus and knowledge on this patient group within the staff in the ED can lead to higher accuracy of diagnostics. Second, in the new diagnostic pathway emergency physicians perform both the ultrasound and clinical examination of the patients. The availability of radiologist in hospitals are often more limited and may result in a prolonged stay for this patient group. With different specialties investigating the patient one might also lose the overall perspective of the patient condition. International studies have shown that the accuracy of bedside ultrasound by the ED physicians is both cost effective and safe.²² Standardized use of ultrasound by the ED physicians may lead to an increased early detection of DVT, which in turn will be both cost effective and improve the overall patient care.²³⁻²⁵

The main objective of this study is to evaluate if one can reduce LOS for patients with suspected DVT in the ED. The study found that by implementing an ED diagnostic pathway one can significantly reduce LOS with 23%. Studies of direct comparison to this patient populations are few. In a study from St. Olav's Hospital on hip fractures from 2004, they found that by establishing a Fast Track system for patients with suspected hip fracture both length of stay and time to surgery were significantly decreased.²¹ This empathize the importance of establishing alternative pathways for different patient population presenting to the ED. The overall issue of increasing visits to the ED, both nationally and international, emphasize the need of thinking differently to meet the challenges of the health care system in the future.^{11,12} Reducing LOS for one patient population might not be enough to meet the problem. However, this is a factor of relevance to the topic.

The time of input to the ED is important to help on crowding. Studies have shown that the patient flow is lower during night and early mornings, while it increases in the afternoon.¹¹ Between 2018 and 2019 the number of patients visiting before noon significantly increases. At the same time, it is a significantly decrease of patient visits between 12 pm and 18 pm, which is known to be the busiest hours. The change of influx to a less busy time shows the importance of planning health care service, and in turn maximizing the resources available at any time.

After the diagnostic pathway is implemented number of patients returning for a scheduled appointment increases significantly. The emergency physicians perform ultrasound as distal as vena poplitea, while the radiologist also is trained to detect thrombosis more distally.

According to the algorithm of the diagnostic pathway (figure 1), patients presenting with a positive D-dimer should be scheduled for a new examination after one week, even if the ultrasound is negative. However, this is not the case for all the patients in this study. Even if several patients have a negative D-dimer and the ultrasound do not detect a thrombosis as distal as vena poplitea, they returned for a new examination. A reason for this can be that they have moderate to high pretest probability of a DVT and thereby a high clinical suspicion. The study is not designed to evaluate the specific cases more thorough, and further research on the topic may be of importance to reduce unnecessary visits to the ED, both to reduce crowding and for increased patient satisfaction. Another factor to this is the use of anticoagulation between the check-ups. Even if international studies have suggested that a delay in anticoagulant treatment could negatively impact the prognosis, few patients are started with anticoagulation treatment between the appointments in this study.¹⁸ This is a finding of importance for reevaluation and for optimizing of the quality of work in the diagnostic pathway.

In a large cross-sectional study from a urban ED in Dublin from 2019, they evaluate if number of patients with suspected DVT still are treated as in-patients, despite the evidence that outpatient treatment is both safe and cost effective.^{4,19} This study shows that 68% of all patients are treated in the outpatient setting during their study period.⁴ In our study we found that after the implementation of a diagnostic pathway it is an increase of 23% who are treated in the outpatient setting. A reason to this can be that emergency medicine as an own specialty leads to a higher competence in front in the ED, and in turn it can be an important factor to reduce unnecessary admissions for low acute conditions, such as DVT.¹¹

Besides reducing the overall time spent in the ED, it is suggested that reducing LOS might lead to better patient satisfaction. In 2004, a review of the literature on patient satisfaction in EDs across the USA was done.²⁶ In this study waiting time is considered as an important factor, although the strongest predictor is the interpersonal interactions with the ED physicians. This might empathize the importance of having emergency physicians in front in the ED.¹¹ Patient satisfaction is not a variable in this study, but can be an item for future research.

Limitations

This study has several limitations. First, it is a retrospective descriptive study. The logistic data for each patient has been manually registered, and for some variables there are incomplete data due to human bias. Second, due to the distinct features of the Norwegian healthcare system the number of studies for comparison with direct relevance to our situation was low.

Conclusion

This study highlights the importance of health care planning for patients with suspected low acute conditions. The study shows that by implementing an own diagnostic pathway with emergency physicians in front, time spent in the ED for patients with suspected DVT is significantly reduced. Further, the study shows that the number of patients treated in an outpatient setting increases and that it is possible to shift the time of patient input towards mornings, a time known to be less busy in general. All these factors are important to reduce ED crowding and to potentially reduce health care costs. There is not found a higher mortality rate, nor rate of complication after implementation of the diagnostic pathway. At the same time, it is a higher number of patients with control appointments. This study has only given an overview of the topic. Further development of the diagnostic pathway and research on the topic is necessary to meet its full potential.

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All authors participated in the study design. Lars Næss-Pleym extracted the data from PAS and Acute ED database. Ingvild Nordby Meese carried out the data analysis and drafted the manuscript. All authors interpreted the data and revised the manuscript.

Disclosure statement

No potential conflict of interest was reported by the authors.

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