

Semi-rigid knee splints for injury and risk of symptomatic venous thromboembolism: an exploratory retrospective analysis

Ross Hunter ¹, Jamie Gray Cooper ², Asleigh Philips¹

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¹Emergency Medicine, Aberdeen Royal Infirmary, Aberdeen, UK
²Emergency Department, Aberdeen Royal Infirmary, Aberdeen, UK

Correspondence to

Dr Ross Hunter, Emergency Medicine, Aberdeen Royal Infirmary, Aberdeen, UK; ross.hunter6@nhs.scot

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ABSTRACT

Introduction Patients with lower limb injuries are commonly discharged from the ED with the affected area immobilised. Rigid casting of the lower limb is known to be a risk factor for the development of venous thromboembolism (VTE), making thromboprophylaxis in this population an important consideration for clinicians in the ED. The use of structured risk assessment methods (RAMs) to evaluate VTE risk and recommend thromboprophylaxis to those at higher risk is widespread in the UK. However, the evidence informing this practice is nearly exclusively based on studies of patients with rigid lower limb casts but many patients with knee injuries, including some with significant thrombotic risk factors, are managed in semi-rigid ('cricket') knee splints. These are both removable and allow free movement of the ankle, but the baseline risk of VTE and the performance of different RAMs in this population are not known.

Methods Consecutive patients (≥ 14 years) discharged from the ED at Aberdeen Royal Infirmary, between 1 January 2010 and 31 December 2021, in a semi-rigid knee splint were identified retrospectively and followed up to 3 months after splint removal for the development of symptomatic VTE. Secondly, data permitting the assessment of five different RAMs (NICE, GEMNet, an Aberdeen tool, the Plymouth score (V.2) and the L-TRiP(cast) score) were extracted systematically and compared.

Results In 510 patients (mean age 32 (SD 16) years, 62% male) none received thromboprophylaxis and all completed follow-up. Two patients developed symptomatic VTE (0.4%, 95% CI 0.1% to 1.4%). The different RAMs varied considerably in the proportions identified for thromboprophylaxis from GEMNet (47%) to the L-TRiP(cast) score (2%), but no RAM was able to identify the two patients who progressed to VTE.

Conclusions In our cohort of patients managed in semi-rigid removable knee splints, the risk of symptomatic VTE was low, about 1 in 250, and current methods of VTE risk assessment did not prove clinically useful.

INTRODUCTION

Venous thromboembolism (VTE) is responsible for 25 000 hospital deaths annually in the UK.¹ Temporary lower limb immobilisation after injury increases risk of VTE development,² an important consideration for clinicians discharging patients from the ED. Risk of symptomatic VTE in this population is halved (from 2% to 1%) with pharmacological

Key messages

What is already known on this subject

- ⇒ Lower limb immobilisation in cast is a risk factor for venous thromboembolism (VTE) development in ambulant patients discharged from the ED.
- ⇒ Baseline risk of VTE and performance of risk assessment methods (RAMs) are based largely on patients in rigid casts.
- ⇒ Removable semi-rigid splints are commonly used in the ED to manage knee injuries but the implications for the development of VTE and how best to establish risk are not known.

What this study adds

- ⇒ In a retrospective study, the risk of VTE in 510 patients discharged from the ED in removable semi-rigid knee splints was shown to be low, about 1 in 250 patients.
- ⇒ Current RAMs were not clinically helpful in this cohort of patients in this study.

thromboprophylaxis^{3,4} but such a strategy may not be suitable or cost-effective for all patients.

The National Institute for Health and Care Excellence (NICE) advises that thromboprophylaxis should be considered in such patients if the risk of VTE outweighs the risk of bleeding.⁵ Different risk assessment methods (RAMs) have been developed to bring structure to this process, but evidence for recommendations comes almost exclusively from studies of rigid immobilisation of the knee and/or ankle in a plaster or resin cast. The use of removable semi-rigid knee ('cricket') splints for injury is common and meets the NICE definition for lower limb immobilisation. However, it is unclear whether these splints confer a similar risk of VTE to rigid casts, and whether existing RAMS should be applied conventionally to this cohort of patients.

Our aim was to determine the incidence of symptomatic VTE in patients discharged from the ED in a removable semi-rigid knee splint and to compare five RAMs in this population.

METHODS

Consecutive patients ≥ 14 years of age discharged from the Aberdeen Royal Infirmary ED with knee injuries to orthopaedic clinic between 1 January 2010 and 31 December 2012. This period was chosen in order to analyse patients before any

routine VTE screening was performed in this population in our institution. Patients aged 14 and 15 year old were seen in the adult ED in Aberdeen until September 2012. Patients were identified from an ED electronic information system and those managed in knee splints subsequently highlighted by case note review.

Two investigators sequentially, but systematically, extracted data from the initial written ED attendance records, orthopaedic clinic written notes and electronic letters, and regional electronic hospital and primary care records, including results of radiological investigations. Patient, injury and treatment demographics, along with any positive recorded evidence of a VTE risk factor, were entered into a bespoke database that electronically assimilated each of five RAMs: NICE,⁵ GEMNet,⁶ an Aberdeen tool, the Plymouth score (V.2)⁷ and the L-TRiP(cast)⁸ score. A full list of data points collected is available as online supplemental material. Dichotomous risk score outcomes for the NICE,⁵ GEMNet⁶ and the Aberdeen methods were recorded, along with values for the Plymouth score,⁷ examined at thresholds of ≥ 3 and ≥ 2 , and the L-TRiP(cast) score, at thresholds of ≥ 9 and ≥ 8 . Data extraction and exclusion criteria (defined a priori) application were performed independently and blinded to clinical outcome. Any differences were resolved by consensus.

Patients were followed up for 3 months post splint removal for the development of symptomatic VTE. Any instance of radiological investigation for suspected VTE, or sudden unexplained death, were adjudicated independently by two experienced physicians to assign outcome.

Results are expressed as frequencies and percentages with 95% CI, or as mean with SD or median with IQR depending on distribution. Performance of RAMs to identify patients with symptomatic VTE was assessed using two-by-two tables to compare sensitivity, specificity, negative predictive value (NPV) and positive predictive value (PPV).

There was no patient or public contribution, but the subject is among the top 30 research priorities identified by the Royal College of Emergency Medicine and The James Lind Alliance.⁹

RESULTS

Of 1007 ED patients referred, 566 were managed in a semi-rigid knee splint and 56 were further excluded (figure 1), resulting in a study population of 510 patients (mean age 32 (SD 16) years, 62% men). None were prescribed VTE thromboprophylaxis or

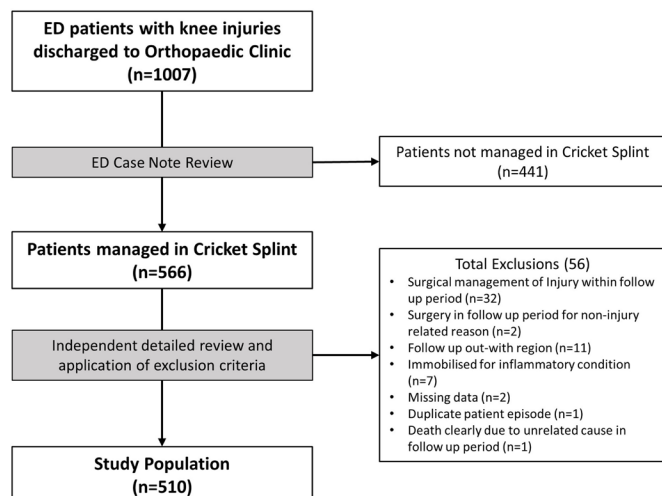


Figure 1 Patient flow diagram.

Table 1 Baseline characteristics of the study population

	Study population
Cohort	510
Age (years, SD)§	32 (16)
Men	316 (62)
BMI (kg/m ² , SD)§	27 (6)
Length of immobilisation (days, IQR)*	14 (9–17)†
Active smoker	139 (27)
Injury and treatment	
Soft tissue injury (knee ligament/tendon/cartilage)	379 (74)
Patella fracture/dislocation	121 (24)
Distal femur or proximal tibia/fibula fracture	10 (2)
Acute severe injury (dislocation/fracture/complete tendon rupture)	195 (38)
Documented initial weight-bearing status	
Partial weight bearing	395 (77)
Full weight bearing	9 (2)
Non weight bearing	5 (1)
Not documented	101 (20)
Other VTE risk data for RAMs	
Previous personal history of VTE	4 (1) (DVT (n=4) and PE (n=0))
First-degree relative with VTE	0
Known thrombophilia	0
Superficial venous thrombosis	3
Gross varicose veins	1
Current use of hormonal therapy	23 (5) (systemic contraception‡ (n=20) and other HRT (n=3))
Pregnancy or <6 weeks postpartum	2
Major active medical comorbidity (eg, CCF, IBD, connective tissue or other inflammatory disease, COPD, sickle cell disease, myeloproliferative disease, SLE, antiphospholipid syndrome, nephrotic syndrome, Rheumatoid, CKD, MS, endocrine)	16 (3)
Pneumonia	0
Active or recent intravenous drug injection into groin	6 (1)
Reduced mobility or bedridden or unable to walk before injury	0
Active cancer or on cancer therapy	2
Cancer in last 5 years	3 (1)
Major surgery within the last 3 months	1
Abdominal surgery in last 6 weeks	1
Hospital admission in the last 3 months	1
Complex lower limb surgery or pelvic fracture in last 6 weeks and advised to have prolonged DVT prophylaxis	0
Dehydration	0
eGFR <30 mL/min/kg ²	0

Data presented as number of patients (%).

*Median and IQR.

†Data for length of immobilisation were available for 499 patients.

‡Systemic contraception was defined as use of the combined contraceptive pill or progesterones (oral or injected or implanted)—not the progesterone-only pill (mini-pill).

§Mean and SD.

BMI, body mass index; CCF, congestive cardiac failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; DVT, deep vein thrombosis; eGFR, estimated glomerular filtration rate; HRT, hormone replacement therapy; IBD, inflammatory bowel disease; MS, multiple sclerosis; PE, pulmonary embolism; RAM, risk assessment method; SLE, systemic lupus erythematosus; VTE, venous thromboembolism.

were already anticoagulated, and all completed follow-up. Baseline population characteristics are reported in table 1.

Two patients (0.4%, 95% CI 0.1% to 1.4%) developed symptomatic VTE. Both were male with a body mass index (BMI) <25 kg/m² and developed pulmonary embolism. The first, a 41-year-old smoker with no other identified VTE risk factors,

Table 2 Performance of NICE, GEMNet, Plymouth V2, L-Trip(cast) (at cut-offs of ≥ 9 and ≥ 8) and the Aberdeen RAM to predict symptomatic VTE at 3 months post cricket splint removal in (a) 399 patients with complete data for all five RAMs and (b) 510 patients after mean BMI data imputed

(a) Patients with data for all RAMs (n=399)	Proportion high risk	VTE at 3 months after splint removed		No VTE at 3 months after splint removed		Sensitivity (95% CI)	Specificity (95% CI)	PPV(95% CI)	NPV (95% CI)
		High risk	Low risk	High risk	Low risk				
NICE	149 (37%)	0	2	149	248	0% (0% to 65.8%)	62.5% (57.6% to 67.1%)	0% (0% to 2.5%)	99.2% (97.1% to 99.8%)
GemNET*	229 (57%)	1	1	228	169	50.0% (9.5% to 90.5%)	42.6% (37.8% to 47.5%)	0.4% (0.1% to 2.4%)	99.4% (96.7% to 99.9%)
Plymouth ≥ 3	27 (7%)	0	2	27	370	0% (0% to 65.8%)	93.2% (90.3% to 95.3%)	0% (0% to 12.5%)	99.5% (98.1% to 99.9%)
Plymouth ≥ 2	114 (29%)	0	2	114	283	0% (0% to 65.8%)	71.3% (66.6% to 75.5%)	0% (0% to 3.3%)	99.3% (97.5% to 99.8%)
† L-TRiP(cast) ≥ 9	8 (2%)	0	2	8	389	0% (0% to 65.8%)	98.0% (96.1% to 99.0%)	0% (0% to 3.3%)	99.5% (98.2% to 99.9%)
† L-TRiP(cast) ≥ 8	19 (5%)	0	2	19	378	0% (0% to 65.8%)	95.2% (92.6% to 96.9%)	0% (0% to 16.8%)	99.5% (98.1% to 99.9%)
Aberdeen	105 (26%)	0	2	105	292	0% (0% to 65.8%)	73.6% (96.1% to 99.0%)	0% (0% to 3.5%)	99.3% (97.6% to 99.8%)
(b) Patients with mean BMI (27 kg/m ²) imputed (n=510)	Proportion high risk	VTE at 3 months after splint removed		No VTE at 3 months after splint removed		Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
		High risk	Low risk	High risk	Low risk				
NICE	150 (29%)	0	2	150	358	0% (0% to 65.8%)	70.5% (66.4% to 74.3%)	0% (0% to 2.5%)	99.4% (98.0% to 99.8%)
*GEMNet	242 (47%)	1	1	241	267	50.0% (9.5% to 90.5%)	52.6% (48.2% to 56.9%)	0.4% (0.1% to 2.3%)	99.6% (97.9% to 99.9%)
Plymouth ≥ 3	27 (5%)	0	2	27	481	0% (0% to 65.8%)	94.7% (92.4% to 96.3%)	0% (0% to 12.5%)	99.6% (98.5% to 99.9%)
Plymouth ≥ 2	114 (22%)	0	2	114	394	0% (0% to 65.8%)	77.6% (73.7% to 81.0%)	0% (0% to 3.3%)	99.5% (98.2% to 99.9%)
† L-TRiP(cast) ≥ 9	8 (2%)	0	2	8	500	0% (0% to 65.8%)	98.4% (96.9% to 99.2%)	0% (0% to 3.2%)	99.6% (98.6% to 99.9%)
† L-TRiP(cast) ≥ 8	19 (4%)	0	2	19	489	0% (0% to 65.8%)	96.3% (94.2% to 97.6%)	0% (0% to 16.8%)	99.6% (98.5% to 99.9%)
Aberdeen	107 (21%)	0	2	107	401	0% (0% to 65.8%)	78.9% (75.2% to 82.3%)	0% (0% to 3.5%)	99.5% (98.2% to 99.9%)

*To permit assessment of performance of the GEMNet⁶ and L-TRiP(cast)⁸ RAMs, immobilisation with a semi-rigid knee splint was considered to be 'rigid immobilisation' in application of GEMNet, and 'plaster cast: circular knee cast (ankle free)' considered equivalent to semi-rigid knee in application of L-TRiP(cast).
 BMI, body mass index; NPV, negative predictive value; PPV, positive predictive value; RAM, risk assessment method; VET, venous thromboembolism.

was diagnosed at 33 days (2 days after splint removal) and the second, a 36-year-old non-smoker with no recorded VTE risk factors, presented 13 days after injury while still in splint. Both recovered fully with warfarin treatment, although the former was subsequently diagnosed with a genetic thrombophilia. There were no sudden unexplained deaths.

Absence of BMI data meant retrospective calculation of all five RAMs was only possible directly in 399 individuals. However, a sensitivity analysis performed with imputation of mean BMI (27 kg/m²) allowed calculation of all RAMs in all 510 patients. No RAM identified both individuals who developed VTE and only the GEMNet method classified one patient who developed VTE as high risk. Substantial differences in the number of patients identified for thromboprophylaxis in this population were evident, from 8 (2%) using the L-TRiP(cast) score (≥ 9) to 242 (47%) with the GEMNet method. The low event rate was reflected in the high NPV and poor PPV demonstrated for all RAMs. However, specificity was notably better for both the L-TRiP(cast) score and the Plymouth score at recommended thresholds of ≥ 9 and 3, respectively (table 2).

DISCUSSION

In this study of ambulatory ED patients managed in semi-rigid knee splints, the incidence of symptomatic VTE was about five times less than the 1 in 50 previously reported in those managed in rigid leg casts without VTE prophylaxis.^{3,4} Such a difference

may be attributed to a young population that is largely able to weight bear, managed in removable splints that permit free ankle movement that are only used for around 2 weeks.

While the VTE rate in our population was 0.4% (95% CI 0.1% to 1.4%), all three dichotomous RAMs recommended large numbers of patients receive thromboprophylaxis. Both the Plymouth and L-TRiP(cast) scores performed with better specificity at recognised thresholds of ≥ 9 and ≥ 3 , respectively, but this was also seen, though to a lesser degree, at the lower levels of ≥ 8 (L-TRiP(cast)) and ≥ 2 (Plymouth), perhaps reflecting that an ordinal score may better recognise low thrombosis risk. Nevertheless, none of the RAMs identified both patients in our cohort that developed VTE and were generally of poor clinical utility.

Limitations

Retrospective extraction of information from clinical notes may result in missing data with underestimation of VTE risk. It is also possible that patients had unreported signs and symptoms of VTE and were not investigated, resulting in misclassification of clinical outcome. Lastly, as a single-centre study with a small outcome event rate, findings should be verified in other populations.

Future work should involve prospective comparison of new RAMs, like the TRiP(cast) score,¹⁰ with more established methods. Where possible, evaluation should be reported as an

ordinal score and performance outlined in relation to distinct types of lower limb immobilisation, both to optimise patient safety and to provide cost-benefit for health services.

CONCLUSIONS

In this cohort of ED patients discharged in semi-rigid knee splints, the incidence of subsequent symptomatic VTE was very low. Of five RAMs evaluated, none identified both individuals who developed symptomatic VTE and their clinical usefulness in our population was poor. The authors advocate the importance of shared clinician patient decision-making with provision of written VTE information.

Twitter Jamie Gray Cooper @JamieCooperEM

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Competing interests None declared.

Patient consent for publication Not applicable.

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ORCID iDs

Ross Hunter <http://orcid.org/0000-0002-0889-3101>

Jamie Gray Cooper <http://orcid.org/0000-0003-3812-7026>

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