

# Venous ligation versus venous repair: does the procedure impact venous thromboembolism risk?

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## ABSTRACT

**Background** Traumatic lower extremity venous injuries are most commonly managed with either a vein ligation or repair procedure. Venous injuries are associated with an increased risk of developing venous thromboembolisms (VTE), but little is understood with regard to how specific surgical treatments may impact the risk of developing either a deep vein thrombosis (DVT) or a pulmonary embolism (PE). In this study of lower extremity venous injuries, we hypothesized that venous ligation would be associated with an increased risk of DVT but a lower risk of PE when compared with venous repair.

**Methods** Patients were identified from the National Trauma Data Bank (2008 to 2014) with at least one iliac, femoral, popliteal, or tibial venous injury and who received either a vein ligation or repair. The patients were then compared based on the type of procedure and the location of the injury to assess the risk of DVT and PE between the groups.

**Results** A total of 1214 patients were identified. There was no difference between patients who received a vein ligation versus a repair with respect to age, injury severity score, or initial systolic blood pressure. There was no difference in the odds of developing either a DVT or PE between patients who were treated with vein ligation versus repair. There was also no difference in VTE rates when stratified by the location of the injury.

**Conclusions** In individuals with lower extremity venous injuries, there is no difference in the rate of DVT or PE complications when comparing venous repair and ligation procedures. The role of anticoagulation remains to be elucidated following operative treatment.

**Level of evidence** Therapeutic/Care Management, Level IV.

## INTRODUCTION

Peripheral venous injuries are managed by both vascular and trauma surgeons through a variety of techniques. It is generally accepted that, when feasible, the goal should be to repair the vein to limit both the short-term and long-term sequelae associated with ligation. Unfortunately, in the trauma population, this is not always an option due to the specific injury and the need to prioritize hemodynamic stability.<sup>1</sup> Ultimately, this requires the surgeon to determine the most appropriate treatment given the nature of the injury, the condition of the patient, and the operative approach required for a repair.<sup>2,3</sup>

Venous injuries are a known risk factor for the development of venous thromboembolism (VTE).<sup>4-6</sup> This risk has decreased through the increased use

of VTE chemical prophylaxis but controversy still exists as to whether this risk can be further mitigated by the surgical approach.<sup>5</sup> More specifically, the question remains as to whether there is a clinically significant difference in VTE outcomes for venous injuries managed with ligation procedures vs repair procedures.

One of the greatest concerns for the development of a deep vein thrombosis (DVT) is the potential for a pulmonary embolism (PE). In a review of 45 popliteal venous repair cases, Tofigh identified 11 PEs, 5 of which were symptomatic.<sup>7</sup> This high rate of PE is in line with previous work by Knudson *et al* in which they completed a review of venous injuries from the National Trauma Data Bank (NTDB) and found a DVT rate of 0.36% and a PE rate of 0.13%.<sup>5</sup> Although both of these studies identified the higher rate of VTEs in venous injuries, they did not compare surgical approaches. In the small studies that have compared operative approaches, there has not been an increased rate of PE associated with one operative approach over the other.<sup>1,8-10</sup>

The purpose of this study is to describe the in-hospital VTE outcomes associated with operative venous injuries in a large population of injured patients. We hypothesized that as a ligation procedure intentionally occludes the vein, ligation would be associated with higher rates of DVT but lower rates of PE when compared with a venous repair.

## METHODS

This is a retrospective analysis of patients with venous injuries included in the NTDB between the years 2008 and 2014. Patients were initially identified based on the *International Classification of Diseases, Ninth Revision* (ICD-9) codes that corresponded with venous injuries to the iliac (902.54), femoral (904.2), popliteal (904.42), tibial (904.5), anterior tibial (904.52), or posterior tibial (904.54) vessels. Below knee injuries, defined as tibial, anterior tibial, and posterior tibial venous injuries, were grouped and considered “distal” for analysis. All patients were then divided based on the procedure they received. Ligation procedures include both excision and occlusion of abdominal and lower limb vein ICD-9 codes (38.67, 38.69, 38.87, and 38.89). Repair procedures included: incision, resection with anastomosis, suture repair, and other repair of vessel procedures for the abdominal and lower limb vein ICD-9 codes (38.07, 38.09, 38.37, 38.39, 39.3, 39.32, 39.5, 39.56, 39.57, 39.58, 39.59, and 39.92). Patients were excluded if they received a lower extremity amputation (84.15 to 84.19). Age, gender, mechanism of injury, initial Glasgow Coma

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**Table 1** Demographics and injury distributions of treatment groups

Population	Ligation (n=394)	Repair (n=820)	P value
Gender (% male)	90.5	88.6	0.3
Age (years)	29±11	30±13	0.14
ISS	16±9	15±9	0.16
SBP (%<90 mm Hg)	27.6	24.7	0.36
Heart rate (beats per minute)	111±29	106±28	<b>0.01</b>
Glasgow Coma Scale	13±4	13±4	0.31
Mechanism (% blunt)	14.1	24.6	<b>0.0001</b>
Iliac vein injury count (%)	139 (35)	222 (27)	<b>&lt;0.001</b>
Femoral vein injury count (%)	168 (43)	383 (47)	
Popliteal vein injury count (%)	51 (13)	163 (20)	
Distal vein injury count (%)	36 (9)	52 (63)	

Means listed with SD. Percentages of injury location are based on columns.

Significant p values bolded.

ISS, injury severity score; SBP, Systolic Blood Pressure on Presentation.

Scale, initial heart rate, initial systolic blood pressure, and calculated injury severity score were collected for all patients who met inclusion and exclusion criteria.

The primary outcome in this study was the development of DVT or PE during the initial hospitalization. This was assessed first by the management approach of the venous injury. Injuries were further stratified to assess if anatomic location was associated with a higher risk of developing DVT or PE. These outcomes were identified directly through the NTDB which includes a list of reported complications during the initial hospitalization. The patient list was cross referenced to the complication list to identify cases of DVT and PE. The NTDB does not contain data on the use of anticoagulants in the acute setting.

Descriptive statistics were calculated for all variables. Independent t-test was used for continuous data, which were reported as mean±SD.  $\chi^2$  tests and OR with 95% CI were used for categorical data, which were reported as percentages. Statistical significance was defined as  $p < 0.05$ .

## RESULTS

There were 4590611 total patients included in the NTDB for years 2008 to 2014. Out of these, 1214 patients had venous injuries that met our inclusion criteria. Overall, the mean age was 29±15 years old and patients were predominantly men. Individuals who underwent a ligation procedure were more likely to have a mechanism of injury that was penetrating and presented with a higher mean heart rate (table 1). A repair procedure was

more commonly performed, compared with a ligation procedure, at each of the assessed anatomic levels ( $p < 0.001$ ) (table 1).

There was no significant difference when comparing VTE outcomes for those who received a ligation procedure to those who received a repair procedure. The OR for developing a DVT was 0.9 (95% CI 0.6, 1.34) and the OR for developing a PE was 0.69 (95% CI 0.19, 2.57). This remained true when the injuries were subdivided into anatomic locations (table 2). Proximal injuries were more commonly associated with the development of DVT and PE. Femoral vein injuries, regardless of treatment approach, were associated with the highest rate of DVT formation, at 11%. Iliac vein injuries were more commonly associated with PE development, with 2.2% of patients with iliac injuries having a PE.

## DISCUSSION

Venous injuries that require an intervention can be managed through a variety of operative approaches. The consequences of each intervention extend beyond that of the immediate procedure to include postoperative complications, such as VTE and venous insufficiency. In this study, we assessed the VTE complications related both to the treatment approach and the location of the venous injury.

We had initially hypothesized that ligation procedures would result in an increased rate of DVT but a lower rate of PE formation, compared with venous repair procedures. Our hypothesis was founded on the fact that, by definition, a ligation procedure will result in thrombus formation distal to the ligation and not allow it to propagate and travel to the pulmonary system. Our hypothesis was not supported in this study as we did not find a difference in the risk of developing a DVT or PE when comparing operative approaches. We think this lack of difference may be related to a surveillance bias. Previous work has shown that the odds of diagnosing a DVT are five times higher in institutions with standardized lower extremity duplex screening.<sup>11</sup> We presume that surgeons who complete a venous repair are more likely to request a venous duplex study to assess the repair and therefore would be more likely to diagnose a DVT. Unfortunately, there is no clear way to analyze that in this retrospective study.

The overall goal of this study was to provide insight into how these patients should be managed postoperatively. There is uncertainty in the literature about the use and timing of therapeutic anticoagulation in these patients. This study suggests that given the previously described increase in DVT rates in the venous injured population and the lack of statistical difference between

**Table 2** Comparison of DVT and PE rates based on anatomic location

Vein	Procedure	DVT (%)	OR	95% CI	PE (%)	OR	95% CI
Iliac	Ligation (n=139)	8.6	0.63	0.32 to 1.28	0.7	0.31	0.04 to 2.73
	Repair (n=222)	13.1			2.3		
Femoral	Ligation (n=168)	13.1	1.37	0.78 to 2.39	1.3	2.3	0.45 to 11.32
	Repair (n=383)	9.9			0.8		
Popliteal	Ligation (n=51)	3.9	0.38	0.08 to 1.69	0	–	–
	Repair (n=163)	9.8			0		
Distal	Ligation (n=36)	5.6	0.71	0.12 to 4.08	0	0	–
	Repair (n=52)	7.7			1.9		
Total	Ligation (n=394)	9.6	0.9	0.6 to 1.34	1	0.69	0.19 to 2.57
	Repair (n=820)	10.6			1.1		

DVT, deep vein thrombosis; PE, pulmonary embolism.

intervention groups, patients should be considered high risk of developing VTEs and both the vein ligation and vein repair groups should be treated similarly (table 2). It is unclear how anticoagulation therapy as well as surveillance imaging patterns may have impacted these results. Given that we cannot account for variations in practice patterns, it is reasonable to initiate anticoagulation in both treatment groups. Our study suggests that the use of prophylactic inferior vena cava filters is not indicated in this population considering the low rate of PE formation and that the filter may promote DVT formation in patients already predisposed to this complication.<sup>12</sup>

This study does have many limitations. Most importantly, this is a retrospective study based on the NTDB that suffers from the possibility of missing data, presentation bias, and treatment bias. It is possible that despite our attempt to be inclusive, patients may have been excluded due to a missing diagnosis or procedure code. Importantly, we are also not able to account for anticoagulation therapy. As the start time, type, and duration of anticoagulation may impact the formation and significance of VTE formation, it is unclear how these results may be impacted by differences in anticoagulation therapy. Additionally, we are not able to account for all the comorbidities, risk factors, or goals of care that may have impact outcomes or decision making. Importantly, we are also not able to analyze if a patient was imaged due to a symptomatic concern for VTE or if it was surveillance imaging for the vascular injury. Without the ability to standardize or account for imaging, it is impossible to fully describe the VTE risk in this population. Despite these limitations, this is the largest study, to date, that addresses the difference in VTE complications associated with ligation and repair procedures for venous injuries from the iliac to below knee veins.

## CONCLUSION

There appears to be no difference in the rate of DVT and PE complications for those patients treated with a vein ligation versus a vein repair procedure. It is unclear how variations in practice patterns may have impacted these outcomes.

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**Contributors** MSF contributed to conception of question and study design, sorted and analyzed data, and wrote and completed final edits of the article. MMK and DMS contributed with research design, data analysis, and comprehensive edits of the article.

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**Competing interests** None declared.

**Patient consent for publication** Not required.

**Ethics approval** This study was exempt from IRB and ethics board review as it was based on the National Trauma Data Bank, a public data bank.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** The National Trauma Data Bank, years 2008 to 2014, was used for this study. All relevant data used in this study were included in the article.

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## REFERENCES

- 1 Quan RW, Gillespie DL, Stuart RP, Chang AS, Whittaker DR, Fox CJ. The effect of vein repair on the risk of venous thromboembolic events: a review of more than 100 traumatic military venous injuries. *J Vasc Surg* 2008;47:571–7.
- 2 Feliciano DV. Pitfalls in the management of peripheral vascular injuries. *Trauma Surg Acute Care Open* 2017;2:e000110.
- 3 Giannakopoulos TG, Avgerinos ED. Management of peripheral and truncal venous injuries. *Front Surg* 2017;4:46.
- 4 Geerts WH, Code KI, Jay RM, Chen E, Szalai JP. A prospective study of venous thromboembolism after major trauma. *N Engl J Med* 1994;331:1601–6.
- 5 Knudson MM, Ikossi DG, Khaw L, Morabito D, Speetzen LS. Thromboembolism after trauma: an analysis of 1602 episodes from the American College of surgeons national trauma data bank. *Ann Surg* 2004;240:490–6.
- 6 Bermudez KM, Knudson MM, Nelken NA, Shackelford S, Dean CL. Long-Term results of lower-extremity venous injuries. *Arch Surg* 1997;132:963–7.
- 7 Tofigh AM, Karvandi M. Incidence and outcome of pulmonary embolism following popliteal vein repair in trauma cases. *Eur J Vasc Endovasc Surg* 2011;41:406–11.
- 8 Allen CJ, Hsu A, Murray CR, Meizoso JP, Ray JJ, Schulman CI, Livingstone AS, Lineen EB, Ginzburg E, Namias N, et al. Risk of pulmonary embolism with repair or ligation of major venous injury following penetrating trauma. *J Trauma Acute Care Surg* 2015;78:580–5.
- 9 Magee GA, Cho J, Matsushima K, Strumwasser A, Inaba K, Jazaeri O, Fox CJ, Demetriades D. Isolated iliac vascular injuries and outcome of repair versus ligation of isolated iliac vein injury. *J Vasc Surg* 2018;67:254–61.
- 10 Frank B, Maher Z, Hazelton JP, Resnick S, Dauer E, Goldenberg A, Lubitz AL, Smith BP, Saillant NN, Reilly PM, et al. Venous thromboembolism after major venous injuries: competing priorities. *J Trauma Acute Care Surg* 2017;83:1095–101.
- 11 Shackford SR, Cipolle MD, Badiie J, Mosby DL, Knudson MM, Lewis PR, McDonald VS, Olson EJ, Thompson KA, Van Gent J-M, et al. Determining the magnitude of surveillance bias in the assessment of lower extremity deep venous thrombosis: a prospective observational study of two centers. *J Trauma Acute Care Surg* 2016;80:734–9.
- 12 PREPIC Study Group. Eight-Year follow-up of patients with permanent vena cava filters in the prevention of pulmonary embolism: the PREPIC (prevention Du Risque d'Embolie Pulmonaire par interruption cave) randomized study. *Circulation* 2005;112:416–22.