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The Rate of Deep Venous Thrombosis in Patients Undergoing Endovascular Aneurysm Repair or Open Aneurysm Repair

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Abstract

Objective: To examine the incidence of Deep Venous Thrombosis (DVT) and associated risk factors following abdominal aortic aneurysm repair procedures: Open Aneurysm Repair (OAR) and Endovascular Repair (EVAR).

Methods: We reviewed all patients who underwent elective EVAR and OAR repair from the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) from 2005 to 2011. We further analyzed the incidence of DVT according to different risk factors and repair type.

Results: DVT rates were 0.5% (EVAR) and 1.3% (OAR) group with statistical significance ($p<0.0001$). The analysis also showed many risk factors associated with increased thrombosis as discussed in this paper and some showed to have a protective effect.

Conclusion: Higher incidence of DVT was found in patients who underwent OAR *vs*. EVAR. It was also found that prolonged hospitalization, infection, and blood transfusions were associated with higher rates of thrombosis. Lower ASA class was a factor associated with lower DVT rate in both repair groups.

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Introduction

Deep Venous Thromboembolism (DVT) is a major cause of morbidity in the hospitalized patient. It is especially common in patients that are immobilized for long periods of time such as post-surgical patients. It is estimated that the incidence of DVT in vascular surgery patients is approximately 1.3%, significantly lower than the 19% incidence of DVT in patients undergoing general surgery [1,2]. However, DVT is a common complication after vascular surgery and has a high incidence if there is no prophylaxis administered [3]. Rates of DVT may be lower for vascular patients because it is common practice to administer intraoperative heparin during vascular surgery [4,5].

With regards to DVT as a complication of vascular surgery, there is little discussion of its incidence specifically for patients undergoing Abdominal Aortic Aneurysm (AAA) repair. Several studies have compared the rates of DVT between Endovascular Aneurysm Repair (EVAR) and Open Aneurysm Repair (OAR), but did not show any confident association in DVT and type of repair. In 2009, de Maistre et al. [6] showed that the incidence of DVT was 5.3% in EVAR and 10.2% in OAR; however their findings were not statistically significant at the time. A more recent study by Morgan et al. [7] showed that 4% of their patients had DVT following EVAR, however their study only evaluated rates of DVT in patients that underwent a percutaneous procedure and they did not address rates of DVT in the open aneurysm patients. Eagleton et al. [8] also reported a low incidence of DVT in patients undergoing AAA repair but their study was also done in the EVAR group. In order to gain a clearer understanding of the incidence of DVT with relation to the type of AAA repair done, we undertook a study that compared rates of DVT in EVAR and OAR subgroups.

Methods

We conducted a database review of all elective Abdominal Aortic Aneurysm Repairs reported to the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) from 2005 to 2011. A total of 22,752 patients were recorded in the database that underwent an open or endovascular abdominal aortic aneurysm surgery. The patients were then divided into

"EVAR" and "OAR" groups. A univariate analysis was conducted of the incidence of DVT in EVAR and OAR groups. We also identified risk factors for Deep Venous Thromboembolism (DVT) development and grouped them as "pre-existing factors, intraoperative factors, and postoperative complications". Patients with each risk factor were analyzed for such factors as percentage of positive DVT, negative DVT, and odds ratio for DVT. A p value was estimated to ensure statistical significance of data reported. The incidence of DVT was reported and found through Duplex ultrasound. It is important to note that we excluded patients with malignancy as they are generally in a hypercoagulable state so their incidence of DVT is higher at baseline.

Results

Of the 22,752 patients included in our study, the EVAR group contained 17,046 patients and the OAR group had 5,706. Development of DVT was noted in 90 patients in the EVAR group and in 74 of the patients in the OAR group. Patients with concurrent neoplastic diagnoses were excluded from our analysis because of the known hypercoagulable state associated with neoplasm. DVT rates between EVAR and OAR (0.5% *vs.* 1.3%) was statistically significant (p<0.0001).

The OAR group showed several postoperative factors to be associated with increased thrombosis (Table 1). Factors included prolonged mechanical ventilation greater than 48 h (62.1% *vs.* 16.6%, p=0.01), unplanned intubation (23.6% *vs.* 7.4%, p=0.01), development of pneumonia (38.6% *vs.* 10.4%, p=0.01), cardiac arrest (10.0% *vs.* 2.8%, p=0.01), ruptured aneurysm (41.4% *vs.* 19.3%, p=0.01), presence of sepsis (22.1% *vs.* 5.3%, p=0.01), and septic shock (21.4% *vs.* 5.6%, p=0.01). Upon univariate analysis of the EVAR group (Table 2), risk factors such as preoperative hypertension (71.8% *vs.* 79.6%, p=0.04), septic shock (1.8% *vs.* 0.2%, p=0.01), preoperative transfusion (5.5% *vs.* 0.9%, p=0.01) and postoperative transfusion (16.4% *vs.* 6.8%, p=0.01), postoperative acute renal failure (6.4% *vs.* 0.5%, p=0.01), superficial (4.5% *vs.* 1.7%, p=0.05) and deep surgical site infections (2.7% *vs.* 0.5%, p=0.02) showed a higher incidence in development of DVT. Analysis of patient ASA classification of 3 (55.5% *vs.* 70.4%, p=0.01) showed a protective effect on development of DVT in both types of AAA repair groups. ASA classifications 4 (36.4% *vs.* 21.9%, p=0.01) and 5 (5.5% *vs.* 1.1%, p=0.01), on the other hand were associated with higher risk of postoperative DVT.

Table 1: Factors affecting DVT after OAR.

	Positive DVT	Negative DVT	Odds Ratio	p value
	% of Patients			
Pre existing Factors				
Functional status (totally dependent) before surgery	11.4	6.3	1.9	0.02
Ventilator Dependent	10	3.9	2.8	0.01
SIRS	15.7	7	2.5	0.01
ASA Class				
3	31.4	55.4	0.37	0.01
4	48.6	32.5	1.95	0.01
5	16.4	7.2	2.54	0.01
Ruptured	41.4	19.3	2.95	0.01
Intraoperative				
Emergency Case	51.4	23.5	3.44	0.01
Postoperative Complications				
Return to the OR within 30 days	37.1	11	4.78	0.01
Prolonged ventilation	62.1	16.6	8.22	0.01
Unplanned Intubation	23.6	7.4	3.87	0.01
Pneumonia	38.6	10.4	5.42	0.01
Cardiac Arrest	10	2.8	3.9	0.01
Organ Space Surgical Site Infection	2.9	0.8	3.45	0.04
Pulmonary Embolus	10	0.6	19.75	0.01
Stroke (TIA or CVA)	2.9	0.9	3.08	0.02
Urinary tract infection	15	4.2	4.05	0.01
Sepsis without septic shock	22.1	5.3	4.81	0.01
Septic shock	21.4	5.6	4.61	0.01

*SIRS: Systemic Inflammatory Response Syndrome; TIA: Transient Ischemic Attack; CVA: Cerebral Vascular Attack; ASA: American Society of Anesthesiologists

Discussion

Literature comparing the incidence of DVT in patients undergoing open aneurysm repair *vs.* EVAR is scarce. We used the NSQIP database to compare the incidence of DVT in these two groups. We noted many factors that contributed to developing DVT in both groups; these factors include type of repair performed, ASA classification of the patient, occurrence of intraoperative blood transfusion, and postoperative state. Complete lists of the factors are listed in Table 1 and 2. We will discuss at length a few of the most outstanding observations made in our investigation. The most notable finding was a statistically significant difference in incidence of DVT in two types of AAA repair procedures. It showed DVT incidence of 1.3% in OAR *vs.* a DVT incidence of 0.5% in EVAR, which has not previously been established. The lower incidence of DVT in EVAR group is likely due to it being a procedure with a smaller operative time, blood loss, and length of hospital stay compared to OAR which has been well established in literature. We believe that EVAR being a less invasive procedure plays a large role in having a lower rate of DVT. It is quite conceivable that because EVAR requires disruption of less tissue architecture than OAR, there is less endothelial damage subsequently leading to less of an inflammatory response than would be seen in a more invasive procedure such as OAR. In addition, Yamazami et al. [9] noted that the disease process of aneurysm itself can promote coagulation. As we know, invasive procedures induce large inflammatory responses and promote a thrombotic state. Since aneurysms inherently promote coagulative states and EVAR involves less inflammation and tissue disruption than OAR, it would be expected that there is less incidence of DVT in EVAR than in OAR.

In addition to finding factors that were associated with high DVT incidence we noted that low ASA classification had a protective effect on DVT incidence. ASA classification is based on a five category physical status classification system of the American Society of Anesthesiologists. Patients with more severe systemic disease are categorized in a higher ASA classification. To date, there has been little research done on ASA classification and its association with DVT incidence in post-surgical patients. In a study done by Shaikh et al. [10], they examined plastic surgery patients with different ASA classifications and found that the lower the ASA score, the less incidence of DVT. Similarly, our study found that a low ASA score of 3 showed the odds ratio of 0.37 in OAR and 0.52 in EVAR, whereas ASA score 4 showed 1.95 in OAR and 2.04 in EVAR. We suspect that this protective effect may be due to the nature of the ASA classification

Table 2: Factors affecting DVT after EVAR.

	Positive DVT	Negative DVT	Odds Ratio	p value
	% of Patients			
Pre-existing Factors				
Functional Status (totally dependent) before surgery	6.4	1.1	6.12	0.01
Ventilator Dependent	7.3	0.6	13.48	0.01
Hypertension requiring medication	71.8	79.6	0.65	0.04
Septic Shock	1.8	0.2	10.1	0.01
SIRS	11.8	2.1	6.3	0.01
Transfusion >4 units in 72 h before surgery	5.5	0.9	6.54	0.01
ASA Class				
3	55.5	70.4	0.52	0.01
4	36.4	21.9	2.04	0.01
5	5.5	1.1	4.98	0.01
Intraoperative				
Emergency Case	28.2	6.7	5.45	0.01
Epidural Anesthesia	0	3.5	0	0.05
Spinal Anesthesia	0	5.5	0	0.02
Myocardial Infarction	2.7	0	0	0.01
Intraoperative Blood Transfusion	16.4	0	0	0.01
Postoperative Complications				
Return to OR within 30 days	33.6	5.1	9.51	0.01
Acute Renal Failure	6.4	0.5	14.88	0.01
Prolonged ventilation >48 h	20	2.3	10.66	0.01
Pneumonia	10.9	1.8	3.47	0.01
Cardiac Arrest	3.6	0.7	5.72	0.01
Bleeding Requiring transfusions	16.4	6.8	2.7	0.01
Superficial SSI	4.5	1.7	2.83	0.05
Deep Incisional SSI	2.7	0.5	5.08	0.02
Organ Space SSI	2.7	0.2	15.8	0.01
Pulmonary Embolus	10	0.2	48.14	0.01
Stroke (TIA or CVA)	16.4	0.4	44.58	0.01
Urinary tract infection	7.3	1.9	4.13	0.01
Sepsis without septic shock	6.4	1.2	5.69	0.01
Septic shock	7.3	1	7.69	0.01

system. Patients that qualify as ASA class 3 have less severe disease than patients of ASA classes 4 and 5. A higher ASA class is essentially categorizing a patient based on having more comorbidities, which is usually associated more inflammatory and clotting processes, and thus more likely to develop DVT.

Our study also found an association between intraoperative blood transfusion and DVT incidence showing that 16% of patients that underwent blood transfusions intraoperatively were positive for DVTs after EVAR. Although red blood cells themselves do not promote thrombotic states, it is likely that transfusion of more than four units is a significant enough amount to induce hemostasis based on large volume infusion. This newly created hemostasis is likely what promotes the thrombosis of deep veins in patients during EVAR [11].

In addition to the major risk factors mentioned above, factors such as prolonged hospitalization and complicated postoperative course also contribute to increased incidence in DVT in both repair groups. Increasing hospitalization and thus increased stasis leads to a clear pathological process to increased DVT. A more complicated postoperative course can contribute to higher incidence of DVT because it promotes a prolonged inflammatory state leading to more coagulation and can lead to a prolonged stay. It has been shown by Fletcher et al. [12] that despite prophylactic therapy there is still an undesirable incidence of DVT following vascular surgery. It is important to investigate the incidence of DVT in both types of AAA repair very carefully to determine which patient may be at a higher risk. Moving forward, it would be ideal to continue to investigate the incidence of DVT in AAA repair after more controlled DVT prophylaxis and postoperative DVT treatment.

This study was based on information gathered from the NSQIP database. We realize that our study comes with limitations such as lack of anticoagulation status of patients before, throughout, and after surgeries. The database also does not include follow up of patients past 30 days postoperatively, which may under-represent the number of venous thromboemboli in patients after vascular surgery. However, using such a database also provided some strength to our study. Conducting a study based on evidence from a national database allowed us access to a large sample size with a wide variety of associated risk factors. We were able to analyze DVT incidence with precise confidence intervals.

Conclusion

We found a few notable associations between DVT and the type of AAA repair upon completing our study. Our most significant observation was a statistically significant lower rate of DVT in patients that underwent EVAR (0.5%) compared to OAR (1.3%). This is consistent with other literature on AAA repair and DVT incidence, which have shown lower incidences of DVT in less invasive procedures. Another observation made from this study was that lower ASA class had a protective effect on DVT development post aneurysm repair. This is relatively new data as there is scarce literature on how ASA class affects DVT incidence. Finally, the more predictable observations were that risk factors such as prolonged hospitalization, complicated postoperative course, and high ASA class were noted to be associated with increased risk of DVT in both repair groups.

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