REVIEW

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Role of endovascular peripheral vascular trauma: review article

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ABSTRACT

Traumatic peripheral vascular injuries are significant contributors to disability and mortality in both civilian and battlefield contexts. These injuries typically result from penetrating or blunt trauma, with iatrogenic arterial injury (IAI) also being a common pattern. Over time, the management of such injuries has improved across various environments and conflicts. Peripheral vascular injuries encompass a range of types, including vasospasm, contusion, intimal flaps, disruptions, hematomas, external compression, lacerations, transections, and focal wall defects. Clinical manifestations often involve shock due to severe bleeding and limb necrosis from tissue and organ ischemia. Diagnostic tools such as ultrasound, computed tomography angiography (CTA), and magnetic resonance angiography (MRA) are invaluable for assessing these injuries, with angiography remaining the gold standard. Immediate control of hemorrhage and swift restoration of blood flow are primary treatment goals. The purpose of writing this literature review is to review in more depth the role of endovascular peripheral vascular trauma. The search for articles was conducted to address the problem formulation using five electronic databases of PubMed, EMBASE, Cochrane, Scopus and Google Scholar. The keywords used are "peripheral vascular trauma, endovascular, and open surgery Operative interventions include vascular suturing, ligation, wall repair, and reconstruction using prostheses or grafts. Endovascular techniques like embolization, balloon dilation, and covered stent implantation are also essential. While surgical procedures traditionally dominate treatment, endovascular approaches offer promising alternatives. They are proven to be safe, effective, and increasingly preferred for certain patients. In summary, rapid diagnosis and timely surgical or endovascular interventions are crucial for managing traumatic peripheral vascular injuries. Despite advancements, several unresolved issues require further investigation to refine treatment strategies and optimize outcomes.

Keywords: Endovascular procedures, peripheral vascular trauma, surgical procedure.
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INTRODUCTION

Peripheral vascular injuries significantly contribute to morbidity among trauma patients. It has been observed that up to 5% of individuals with extremity injuries also present with concurrent vascular lesions. Traumatic vascular injuries present as common emergencies, influenced by environmental factors and temporal dynamics. The management approach for these injuries has evolved, transitioning from simpler to more complex interventions, from invasive to noninvasive techniques, and from uniform to diversified methodologies. While modern medical advancements offer significant benefits to patients with vascular injuries, traditional treatment modalities continue to play a crucial role. Therefore, careful consideration is warranted when determining the future direction of vascular injury management, whether it leans toward modern or conventional methodologies.[1]

In the context of surgical emergencies, traumatic vascular injuries predominantly affect blood vessels and arteries, typically manifesting as hemorrhage, often seen in central body injuries, and ischemia, which is common in peripheral arterial injuries. Untimely management of vascular trauma can result in disability or mortality, especially in cases involving limb vascular injury. Vascular surgeons have faced considerable obstacles in the identification and treatment of vascular injuries since the 20th century.[2,3]

Trauma remains a leading cause of mortality. In Australia, there were 11,246 trauma-related deaths, with 71% occurring outside healthcare facilities, primarily due to transportation accidents (32%) and hangings (24%). In England, over a decade, there were 40,680 cases of trauma among adolescents aged 16 to 24, with road traffic collisions accounting for the majority (50.3%). Three percent of all severe injuries are vascular in nature. While thoracic aortic injury happens about five times more commonly, abdominal aortic injury only accounts for 0.1% of all trauma admissions. According to published research, the chest accounts for 20.1% of vascular trauma patients, and 71% of these instances necessitate prompt surgical intervention.[4,5] The purpose of writing this literature review is to review in more depth the role of endovascular peripheral vascular trauma.

METHODS

The search for articles was conducted to address the problem formulation using five electronic databases PubMed, EMBASE, Cochrane, Scopus, and Google Scholar. The keywords used are peripheral vascular

trauma, endovascular, and open surgery.

This research used the inclusion criteria of vascular injury, emergency room, endovascular, and open surgery, which is the research area of therapy with study design of systematic reviews and English full-text articles, while the exclusion criteria were incomplete data or inaccessible full text. The literature search was completed on September 12th, 2023. The obtained literature was critically appraised using the validity-importance-applicability (VIA) framework, utilizing the etiology worksheet from the Oxford Centre for Evidence-Based Medicine. The level of evidence was determined using the Oxford Centre for Evidence-Based Medicine 2011 guidelines.[6]

RESULTS

Epidemiology Peripheral Vascular Trauma

Patients who expire before reaching the hospital often succumb due to major vessel damage. For example, aortic trauma resulting from gunshot wounds remains one of the most challenging vascular injuries, with a mortality rate reaching nearly 87.5%. The femoral vessel is frequently affected, accounting for almost 70% of all arterial injuries, while popliteal arterial injuries constitute 19% of all extremity arterial traumas among civilian populations. Vascular injuries can lead to severe complications, underscoring the critical importance of early diagnosis and timely treatment.[6]

One leading cause of death is peripheral vascular trauma. In Australia, there were 11.246 trauma deaths, with 71% of those deaths occurring outside of hospitals, according to data from the Victorian State Trauma Registry and the National Coronial Information System. Transport incidents (32%) and hangings (24%) were the leading causes of injuries. Between 2008 and 2017, there were 40, 680 cases of trauma among adolescents (ages 16 to 24) in England. Teenagers' trauma is still primarily caused by car accidents (50.3%).[7] Of all trauma admissions, the incidence rate of abdominal aortic damage is a mere 0.1%. Abdominal aortic injuries occur approximately five times less frequently than thoracic aortic injuries. According to published research, abdominal aortic injuries occur approximately five times less frequently than thoracic aortic injuries.[5] According to published research, the chest accounts for 20.1% of vascular trauma cases. Due to damage to the major vessels, 71% of these individuals passed away before they could reach the hospitals.[5] Gunshot-induced aortic trauma, for instance, is still one of the most difficult vascular injuries to treat, with a death rate of around 87.5%. The femoral vessel, which accounts for around 70% of all arterial injuries, is one of the most frequently injured vascular structures.[4] Among civilian populations, popliteal arterial injuries account for 19% of all extremity arterial injuries.[8] Timely diagnosis and treatment are crucial since vascular damage can result in serious consequences.

Endovascular Management Peripheral Vascular Injury

The use of endovascular techniques in the management of peripheral vascular injuries has seen a significant increase in the past decade. This rise coincides with the growing knowledge among trauma surgeons regarding the capabilities of endovascular interventions and the adaptation of operating rooms to facilitate endovascular procedures in acute trauma patients. When appropriate, endovascular interventions have shown the potential to reduce operating time, estimated blood loss, and iatrogenic injuries at the injury site.[9] However, they may come at a higher cost compared to open surgical approaches. The increased utilization of endovascular interventions for peripheral trauma is also attributed to the availability of experienced physicians proficient in these techniques. A review of the National Trauma Data Bank revealed that the utilization of endovascular interventions for vascular trauma increased from 2.1% in 1994 to 8.1% in 2003. Blunt mechanisms accounted for 55% of vascular injuries, while penetrating trauma accounted for 45%. The most commonly injured vessels in blunt trauma were the iliac, internal carotid, brachial, and thoracic aortic arteries. In penetrating trauma, the brachial artery and superficial femoral artery (SFA) were frequently affected. Although endovascular interventions are used to treat and manage traumatic venous injuries, this review will focus on arterial injuries.[10]

Patients with low-velocity injuries (such as pistol shots or stabbing wounds) in anatomical regions where surgical exposure could prolong bleeding or ischemic complications, or in regions like the internal carotid artery or subclavian artery where there is a higher risk of iatrogenic nerve injuries during vessel exposure, are the best candidates for endovascular interventions. Final endovascular repair may not be as beneficial for injuries that require surgical procedures, such as compartment syndrome, embolectomy, or debridement for high-velocity gunshot wounds or contamination. To reduce the expected amount of blood lost, angiography and proximal balloon occlusion may be helpful for certain injuries.[10,11]

The implantation of covered stents and embolization are two other bleeding control techniques. Covered stents or embolization with or without coils can be used to rule out pseudoaneurysms and arteriovenous fistulas. Balloons, exposed metal stents, or coated stents can all be used to address dissections.[12]

The inability to put a wire across the lesion is the only absolute contraindication for endovascular repair in injuries, unless embolization is the intended method of controlling bleeding. Together with the trauma consulting team, a number of relevant contraindications should be taken into account. Hemodynamic instability and uncontrollably bleeding have long been considered strict no-nos for endovascular procedures. This is relevant only in the case of an endovascular suite that is distinct from the operating room, though. If direct surgical access is needed, hybrid operating rooms with endovascular capabilities might permit a more flexible application of endovascular procedures in the operating room. While most open repairs would have similar limits, the inability to utilize heparin is a critical factor but not a complete contraindication.[13,14]

Evidence Search Result

The literature search was conducted on September 12th, 2023, using the following electronic databases:

Table 1. Comparison Endovascular vs Open Surgery in Vascular Trauma

No	Title	Author/ year	Methods	Research Result
1	Open vs Endovascular Treatment of Traumatic Peripheral Arterial Injury: Propensity Matched Analysis[15]	Samer Asmar et al, Division of Trauma, Critical Care, Emergency Surgery, and Burns, Department of Surgery, College of Medicine, University of Arizona, Tucson, AZ.	A group of 786 patients was acquired, 262 of whom were endovascular and 524 were open. Individuals who have injuries to their peripheral arteries (brachial, femoral, popliteal, and axillary). Split the intervention into two groups based on the endovascular and open methods. Complications, length of stay (LOS), 30-day readmission, and readmission cost were the outcome measures.	Seroma (4% vs. 2%; p = 0.04) and arterial thrombosis (13% vs. 7%; p<0.01) were more common among hospitalized patients in the endovascular group. A greater 30-day open-reoperation rate (6% vs. 2%; p < 0.01) and 30-day readmission (11% vs. 7%; p = 0.03) were associated with endovascular repair.
2	Endovascular management for peripheral arterial trauma: The new norm?[16]	Anand Ganapathy et al, Department of Surgery, Baylor College of Medicine, Houston, TX, USA.	Retrospective analysis of patients with injuries to the popliteal, superficial femoral, axillary, and subclavian arteries who were admitted to a Level I Trauma Center. From 2009 to 2015, open or endovascular repair was performed.	Early results showed no statistically significant difference between endovascular and open procedures. Endovascular treatment seems to have some benefits in terms of: complicating anatomy; lowering blood product consumption. Open repair may still be preferable for patients whose injuries cause severe external blood loss or free bleeding.
3	Operative Treatment and Clinical Outcomes in Peripheral Vascular Trauma: The Combined Experience of Two Centers in the Endovascular Era[17]	Ilenia D'Alessio School of Vascular Surgery, University of Milan, Milano, Italy.	Data collected between 2009 and 2017 by the emergency departments of two hospitals in the greater Milan area were subjected to a retrospective analysis. We gathered data on all patients who had limb-related arterial injuries, including demographics, damage patterns, clinical status upon admission, therapy (open or endovascular), and survival and limb salvage rates.	Rarely do isolated artery traumas of the extremities occur; instead, they typically include individuals who have suffered numerous traumas. There are still disagreements over the diagnosis and course of care for these patients, despite advancements in surgical methods. The majority of our cases (n = 46) were treated with open surgery. It's critical to take the patients' overall health and the location of the lesions into account. Furthermore, in order to give patients of repeated trauma the best medical care possible, we advise a multidisciplinary approach.

DISCUSSION

In general, endovascular therapy has become a more commonly used approach than open surgery in the management of peripheral vascular trauma. This trend can be attributed to several factors, including advancements in endovascular technology, the advantages offered by this method, and the proven outcomes demonstrated in studies and clinical experience.[17] Some reasons why endovascular therapy is more commonly utilized in the management of peripheral vascular trauma are due to non-invasiveness, Endovascular therapy involves catheter-based procedures through small incisions, which are significantly less invasive compared to open surgery involving large incisions and extensive tissue dissection.[18] Besides it, endovascular procedure had faster recovery. Patients undergoing endovascular therapy tend to experience faster recovery due to reduced tissue trauma and shorter hospital stays compared to open surgery. Endovascular therapy also carries a lower risk of intraoperative bleeding, particularly in complex cases of peripheral vascular trauma. Endovascular therapy has proven to be an effective method in managing peripheral vascular trauma, exhibiting high success rates and satisfactory long-term outcomes.[19]

However, it is important to note that each case of peripheral vascular trauma has unique characteristics and requirements. Endovascular therapy may not be suitable for all cases, especially in complex or extensive vascular injuries. In such situations, open surgery may remain the preferred option. The choice of the most appropriate treatment approach should be based on a comprehensive evaluation by a trained medical team, considering factors such as injury complexity, location, the expertise of the surgical team, and the availability of required equipment.[15]

Although endovascular therapy has become a more common choice in the management of peripheral vascular trauma, there are several reasons why individuals may prefer open surgery over endovascular therapy in certain cases. First, the complexity of Injury: In cases of complex or extensive peripheral vascular injuries, endovascular therapy may not

be sufficiently effective in repairing the damage. Open surgery provides direct access to the injured artery or vein, allowing for precise exploration and repair. Second, Large Vessel Size in cases where the involved blood vessels have a large diameter, particularly major arteries, open surgery is often preferred. Open surgery enables direct manipulation of large vessels and allows for the use of more precise suturing techniques. Technical or Equipment Limitations which is endovascular therapy requires specialized equipment and adequate technical skills. If the facility or medical team lacks access to the necessary endovascular equipment or is less experienced in the procedure, open surgery may be a more feasible option. Fourth, Emergency Situations: In emergency situations involving severe bleeding or life-threatening ischemia, open surgical intervention can be performed quickly and provide direct control over the bleeding or restoration of disrupted blood flow.[20]

Physician Preferences or Experience: Some vascular surgeons may have preferences or specialized expertise in performing open surgery and may feel more comfortable with that approach. It is important to note that the decision between endovascular therapy and open surgery in the management of peripheral vascular trauma should be based on a thorough evaluation by an experienced medical team. Each case should be individually assessed, considering the characteristics of the injury, complexity, location, equipment availability, and the expertise of the medical team.[20]

This study has the advantage of discussing current and detailed topics from epidemiology, and management explanations, to elaboration of research data. However, this study only used 3 journals that elaborated on the differences between Endovascular and Open Surgery in Vascular Trauma. This research is also limited to a review and does not carry out deeper analysis to determine the significance of the research results.

CONCLUSION

Endovascular therapy is generally more commonly used than open surgery in the management of peripheral vascular trauma. This is due to the advantages of endovascular therapy, including its non-invasive approach, faster recovery, lower risk of bleeding, and proven effectiveness in studies and clinical experience. However, in cases of complex peripheral vascular injuries, large vessel size, technical or equipment limitations, emergency situations, or physician preferences and expertise, open surgery remains a relevant option. The decision regarding the best treatment approach should be made based on a thorough evaluation by an experienced medical team, considering the characteristics of the injury, complexity, location, equipment availability, and expertise of the medical team. Therefore, further studies with different study designs and more developed methods are needed to develop this research.

DISCLOSURES

Ethical Considerations

None.

Conflict of Interest

The authors have no conflict of interest.

Author Contribution

All authors similarly contribute to the thinking about from the investigate concepts, information acquisitions, information investigation, factual investigations, changing the paper, until detailing the consideration comes about through publication.

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