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Review Article

Comparative therapeutic efficacy of endovascular embolization versus open surgical intervention in the management of hepatic visceral aneurysms: a critical analysis of clinical outcomes and procedural considerations

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ABSTRACT

Hepatic visceral aneurysms represent a rare yet clinically significant vascular pathology with potentially life-threatening complications, including rupture and hemorrhage. The optimal therapeutic approach—endovascular embolization or open surgical repair—remains a subject of ongoing debate within the field of vascular and interventional medicine. This article systematically evaluates the comparative efficacy, perioperative morbidity, long-term patency, and procedural complications associated with these two principal treatment modalities. Endovascular techniques, including transcatheter arterial embolization (TAE) and coil embolization, offer minimally invasive advantages, such as reduced hospitalization duration and lower immediate postoperative morbidity. Conversely, open surgical intervention, though more invasive, may provide definitive aneurysm exclusion and durability in select cases, particularly for complex or large aneurysms. Clinical decision-making must account for anatomical considerations, hemodynamic stability, and patient comorbidities. This review synthesizes current evidence to guide clinicians in selecting the most appropriate intervention for hepatic visceral aneurysms, emphasizing a patient-tailored approach to optimize outcomes.

Keywords: Hepatic artery aneurysm, Visceral aneurysm management, Endovascular embolization, Open surgical repair, Vascular surgery, Interventional radiology, Aneurysm rupture risk, Therapeutic outcomes, Minimally invasive techniques

INTRODUCTION

Hepatic visceral aneurysms, though uncommon, constitute a critical diagnostic and therapeutic challenge in contemporary vascular medicine. These aneurysms, predominantly involving the hepatic artery or its branches, pose a significant risk of rupture, with attendant mortality rates exceeding 30% in acute presentations. The evolution of endovascular techniques has revolutionized the management paradigm, offering an alternative to traditional open surgical ligation or resection. However, the selection between embolization and surgery necessitates a nuanced understanding of anatomical, physiological, and patient-specific factors.[1,2]

Endovascular embolization, facilitated by advancements in interventional radiology, employs coil deployment, liquid embolic agents, or stent-assisted techniques to achieve aneurysm occlusion. Its minimally invasive nature reduces intraoperative trauma and accelerates recovery, making it particularly advantageous in high-risk patients. Despite these benefits, concerns persist regarding long-term efficacy, recanalization risks, and applicability in anatomically complex scenarios.[1,2]

Open surgical intervention, while more invasive, remains indispensable in cases of aneurysm rupture, large saccular configurations, or failed endovascular therapy. Surgical options include aneurysmorrhaphy, ligation, or bypass grafting, each requiring meticulous technical execution to preserve hepatic perfusion. The inherent risks of laparotomy, including visceral ischemia and postoperative complications, must be judiciously weighed against potential benefits.[2]

This article endeavors to delineate the indications, contraindications, and evidence-based outcomes associated with both therapeutic strategies, providing a comprehensive framework for clinicians managing hepatic visceral aneurysms. By integrating contemporary literature and procedural insights, we aim to elucidate the optimal conditions favoring embolization or open surgery, thereby enhancing clinical decision-making in this complex vascular disorder.[3]

INDICATIONS AND CONTRAINDICATIONS

Indications for endovascular embolization

Endovascular embolization has emerged as a first-line therapeutic modality for hepatic visceral aneurysms, particularly in patients with favorable anatomical characteristics and significant comorbidities that preclude major abdominal surgery. This minimally invasive approach is especially indicated in cases of small to medium-sized aneurysms (typically less than 3 cm in diameter) with well-defined necks, as these are amenable to precise coil deployment or liquid embolic agent delivery. Patients presenting with asymptomatic, incidentally detected aneurysms, where prophylactic intervention is warranted to mitigate rupture risk, are ideal candidates for embolization. Additionally, those with acute hemorrhage secondary to aneurysm rupture but who remain hemodynamically stable may benefit from urgent transcatheter arterial embolization (TAE) as a life-saving measure.[4]

High-risk surgical patients, including individuals with advanced cirrhosis, portal hypertension, or severe cardiopulmonary compromise, are particularly suited for endovascular management due to its reduced physiological stress and lower perioperative morbidity. Furthermore, aneurysms located in anatomically challenging regions, such as intrahepatic or distal branch vessels, may be more feasibly treated via catheter-based techniques rather than open exposure. The use of adjunctive endovascular strategies, such as stent-assisted coiling or flow diversion, may expand the applicability of embolization in select cases where preserving distal perfusion is critical.[4]

Contraindications for endovascular embolization

Despite its advantages, endovascular embolization is not universally applicable and carries specific contraindications that must be carefully considered. Anatomical constraints, such as aneurysms with extremely wide necks or fusiform morphology, may preclude stable coil placement, increasing the risk of migration or incomplete occlusion. Similarly, aneurysms arising from the common hepatic artery or celiac trunk may pose technical challenges, as embolization in these regions risks compromising vital collateral circulation, potentially leading to hepatic ischemia or infarction.[5]

Patients with active contrast allergies or severe renal insufficiency may face prohibitive risks from the required iodinated contrast load, necessitating alternative imaging or treatment strategies. Additionally, cases of massive hemorrhage with hemodynamic instability may demand immediate surgical exploration rather than time-consuming endovascular attempts, particularly if vascular access is difficult or delayed. Finally, the presence of concomitant biliary-vascular fistulas or infected (mycotic) aneurysms may favor open surgical debridement and reconstruction over embolization, given the latter's limited ability to address extraluminal infection or structural complications.[5]

Indications for open surgical repair

Open surgical intervention remains a definitive treatment for hepatic visceral aneurysms, particularly in scenarios where endovascular techniques are either anatomically unfeasible or clinically suboptimal. Large aneurysms (exceeding 3 cm) or those with saccular configurations and high rupture risk often necessitate direct surgical ligation, resection, or bypass grafting to ensure durable exclusion. Patients presenting with ruptured aneurysms accompanied by hemodynamic collapse may require emergent laparotomy for hemorrhage control and vascular reconstruction, particularly when endovascular resources are unavailable or unsuccessful.[6]

Surgical repair is also preferred in cases where aneurysm etiology suggests underlying infection (mycotic aneurysms), as open debridement and vascular reconstruction with autologous grafts provide superior infection control compared to endovascular methods. Additionally, aneurysms causing mass effect on adjacent structures, such as bile ducts or portal vasculature, may require open surgical intervention to relieve obstruction and restore normal anatomy. Patients with prior failed embolization or recurrent aneurysms may also benefit from definitive surgical management to achieve long-term stability.[6]

Contraindications for open surgical repair

The invasiveness of open surgical repair imposes significant contraindications, particularly in patients with prohibitive operative risk. Those with decompensated liver disease, severe portal hypertension, or coagulopathy face elevated perioperative mortality due to hemorrhage and hepatic decompensation. Extensive prior abdominal surgeries with dense adhesions may complicate surgical

exposure, increasing the risk of iatrogenic injury to surrounding viscera.[7]

Patients with multiple medical comorbidities, including advanced cardiac or pulmonary disease, may lack the physiological reserve to tolerate major abdominal surgery, making minimally invasive alternatives preferable. Additionally, in cases where the aneurysm is located deep within the hepatic parenchyma or involves multiple distal branches, surgical access may be technically unfeasible without incurring excessive parenchymal damage. Finally, in resource-limited settings where advanced vascular surgical expertise is unavailable, endovascular approaches or conservative management may be more pragmatic despite theoretical advantages of open repair.[7]

The decision between endovascular embolization and open surgical repair for hepatic visceral aneurysms hinges on a multifaceted assessment of aneurysm morphology, patient comorbidities, and institutional expertise. While embolization offers a minimally invasive solution with reduced recovery times, its limitations in complex anatomies and high-risk rupture scenarios underscore the enduring role of open surgery. A tailored, multidisciplinary approach ensures optimal outcomes, balancing procedural risks with long-term therapeutic efficacy.[8]

POSTOPERATIVE AND POST-EMBOLIZATION OUTCOMES

The management of hepatic visceral aneurysms, whether through endovascular embolization or open surgical repair, yields distinct postoperative outcomes that significantly influence clinical decision-making. A comprehensive evaluation of these outcomes must consider immediate procedural success, perioperative morbidity, long-term aneurysm exclusion, and the potential for hepatic vascular complications.[8]

Post-embolization outcomes

Endovascular embolization is associated with favorable short-term outcomes, particularly in terms of reduced procedural morbidity and accelerated recovery. Immediate technical success, defined as complete angiographic exclusion of the aneurysm, is achieved in a high percentage of cases, particularly when using modern coil embolization techniques, liquid embolic agents, or stent-assisted methods. Patients undergoing embolization typically experience minimal postprocedural pain, shorter hospitalization durations, and faster return to baseline function compared to open surgery. The avoidance of laparotomy significantly diminishes the risk of wound-related complications, ileus, and prolonged intensive care unit stays.[8]

However, post-embolization syndrome, characterized by transient fever, nausea, and localized pain due to ischemic tissue response, may occur in a subset of patients, though it is generally self-limiting with supportive management. More concerning are instances of incomplete aneurysm occlusion or early recanalization, which may necessitate repeat intervention. Long-term surveillance is critical, as delayed coil migration or reperfusion of the aneurysm sac can lead to late rupture, particularly in cases where collateral circulation develops around the embolized segment. Additionally, hepatic ischemia or infarction, though rare due to the liver's dual blood supply, may manifest post-embolization, particularly if extensive occlusion of the hepatic arterial branches occurs. Liver function tests may transiently elevate, but clinically significant hepatic dysfunction is uncommon unless preexisting cirrhosis or portal vein thrombosis is present.[8]

Post-surgical outcomes

Open surgical repair, while more invasive, offers definitive aneurysm exclusion with durable long-term results, particularly in complex or large aneurysms. Immediate postoperative outcomes depend on the surgical approach, with aneurysm ligation, resection, or bypass grafting each carrying distinct considerations. Successful surgical intervention typically results in complete aneurysm eradication, with negligible risk of recurrence when proper vascular reconstruction is achieved. However, the inherent invasiveness of laparotomy introduces a spectrum of potential complications, including surgical site infections, incisional hernias, and prolonged postoperative ileus.[9]

Major hepatic resection, if required for aneurysms deeply embedded within the parenchyma, may precipitate transient liver dysfunction, reflected in elevated transaminases and bilirubin levels. In extreme cases, post-hepatectomy liver failure may ensue, particularly in patients with underlying hepatic insufficiency. Vascular complications, such as thrombosis of reconstructed vessels or anastomotic strictures, may compromise hepatic perfusion, necessitating reintervention. The systemic stress of major abdominal surgery also predisposes patients to cardiopulmonary complications, including atelectasis, pneumonia, and venous thromboembolism, particularly in those with preexisting comorbidities.[9]

Long-term outcomes following open repair are generally favorable, with low aneurysm recurrence rates and preserved hepatic arterial flow when reconstruction is meticulously performed. However, the development of adhesions or biliary complications, such as strictures or leaks, may occur as delayed sequelae, particularly in surgeries involving extensive dissection near the porta hepatis.[10,11]

COMPARATIVE CONSIDERATIONS

When comparing postprocedural outcomes, endovascular embolization demonstrates clear advantages in terms of reduced acute morbidity and faster recovery, making it preferable for high-risk patients or those with anatomically

accessible aneurysms. However, its reliance on imaging surveillance and potential for delayed complications necessitates long-term follow-up. Open surgery, while burdened by higher upfront morbidity, provides a more definitive solution in complex cases, particularly for ruptured aneurysms, mycotic aneurysms, or those requiring concomitant biliary or vascular reconstruction.[12,13]

The choice between these modalities should be guided by individualized risk assessment, with multidisciplinary collaboration between interventional radiologists, vascular surgeons, and hepatologists ensuring optimal patient selection and postoperative management. Both approaches have distinct yet complementary roles in the treatment of hepatic visceral aneurysms, and ongoing advancements in endovascular technology and minimally invasive surgical techniques continue to refine their respective outcomes.[14]

CONCLUSION

The contemporary management of hepatic visceral aneurysms represents a complex interplay between evolving endovascular capabilities and established surgical principles, each modality offering distinct advantages contingent upon specific clinical and anatomical variables. The critical appraisal of embolization versus open surgical repair necessitates a nuanced understanding of their respective therapeutic landscapes, where procedural selection transcends mere technical feasibility to encompass comprehensive patient-centered considerations.

Endovascular embolization has undeniably revolutionized the therapeutic paradigm, emerging as the intervention of choice for the majority of hepatic visceral aneurysms owing to its minimally invasive nature, reduced peri-procedural morbidity, and expedited recovery profile. The precision of modern catheter-based techniques, including superselective coil deployment and advanced embolic agents, permits effective aneurysm exclusion while preserving essential hepatic perfusion in carefully selected cases. This approach demonstrates particular efficacy in managing small-to-medium aneurysms with favorable morphology, as well as in high-risk surgical candidates where physiological reserve may not tolerate the hemodynamic stresses of laparotomy.

However, the technique's limitations become apparent when confronting complex anatomical scenarios such as wide-necked or fusiform aneurysms, where the risks of incomplete occlusion or recanalization may compromise long-term therapeutic durability. Furthermore, the imperative for rigorous post-embolization surveillance cannot be overstated, as delayed complications including coil migration or reperfusion demand vigilant radiographic monitoring to mitigate catastrophic late rupture.

Conversely, open surgical intervention maintains its irreplaceable role in the management algorithm, particularly for aneurysms exhibiting anatomical complexity, concomitant infection, or rupture with hemodynamic instability. The definitive nature of surgical repair, whether through aneurysmorrhaphy, ligation, or vascular reconstruction, offers unparalleled durability in properly selected cases, effectively eliminating the long-term surveillance burden associated with endovascular approaches. The procedural invasiveness and associated morbidity of laparotomy, while substantial, may represent an acceptable trade-off when balanced against the life-threatening consequences of aneurysm rupture or the limitations of endovascular alternatives. Surgical management proves particularly indispensable in scenarios requiring concomitant biliary reconstruction or when dealing with mycotic aneurysms where source control and debridement are paramount to therapeutic success.

The decision-making matrix must incorporate multifactorial analysis extending beyond mere technical considerations to include patient-specific variables such as hepatic reserve, comorbid conditions, and functional status. Institutional expertise and resource availability similarly influence this calculus, as optimal outcomes demand not only appropriate modality selection but also execution by proficient multidisciplinary teams. Emerging hybrid techniques and technological advancements in both domains continue to blur traditional boundaries, suggesting future paradigms may increasingly incorporate staged or combined approaches to leverage the strengths of each modality while mitigating their respective limitations.

Ultimately, the management of hepatic visceral aneurysms epitomizes the evolution of modern vascular therapeutics, where neither embolization nor open surgery exists as universally superior, but rather as complementary strategies within an expanding armamentarium. The art of clinical decision-making lies in the judicious application of these interventions through meticulous patient stratification, where anatomical, physiological, and technical factors converge to guide optimal therapeutic pathways. As experience accumulates and technologies advance, continued refinement of selection criteria and procedural techniques will undoubtedly enhance outcomes for this challenging vascular pathology.

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