VER
Vascular & Endovascular Review

Cost–Benefit Analysis Of Modern Endovascular Technologies In Hospital Financial Management

Dr. Sarah Leah Dsouza[1], Vedant Prakash[2], Ms. Girija Paranjpe[3], Dr Praveen P[4], Ms. Viral S Ahire[5], Dr. Amarnath Gupta[6*], Dr Meenakshi Duggal[7]

[1]Assistant Professor, D Y Patil Institute of Master of Computer Applications and Management, Akurdi, Pune (0000-0002-7225-083X).
[2]Assistant Professor, School of Commerce & Management, Sri Balaji University, Pune (0009-0009-4895-6937).
[3]Assistant Professor, D Y Patil Institute of Master of Computer Applications and Management, Akurdi, Pune. (0009-0001-8107-0048).
[4]Assistant Professor, Dr D Y Patil Dnyan Prasad Univeristy's School of Management and Research (0000-0002-8757-2815).
[5]Assistant Professor, D Y Patil Institute of Master of Computer Applications and Management, Akurdi, Pune (0000-0003-0075-2483).
[*6]Sr. Assistant Professor, Sr. Assistant Professor, Balaji Institute of Modern Management (BIMM), SBUP (0000-0002-1895-3219).
7Associate Professor, JSPMs Rajarshi Shahu College of Engineering, Pune (0009-0006-9079-2890).

ABSTRACT

Modern endovascular technologies—such as drug-eluting and bioresorbable stents, endovascular aneurysm repair (EVAR) devices, mechanical thrombectomy systems, and advanced imaging-guided catheters—have transformed the management of cardiovascular and neurovascular disease. While these technologies often improve clinical outcomes, shorten hospital stays, and expand minimally invasive options for high-risk patients, their high acquisition and maintenance costs pose major challenges for hospital financial management. This paper examines the cost–benefit profile of contemporary endovascular technologies from the hospital perspective. It explores direct and indirect cost components, revenue implications, and strategic financial considerations such as case-mix optimization, reimbursement dynamics, and capital budgeting. Conceptual and methodological issues in conducting cost–benefit analysis (CBA) are discussed, including cost-effectiveness, cost-utility, and budget impact evaluation, and how these analytic frameworks can be integrated into routine decision-making by hospital management. Illustrative examples include the evaluation of EVAR versus open surgical repair, endovascular therapy for acute ischemic stroke, and peripheral arterial interventions. The discussion highlights how early investment in high-value technologies, when combined with appropriate patient selection, standardised clinical pathways, and data-driven performance monitoring, can produce favourable financial and clinical outcomes. Conversely, uncritical adoption without robust evaluation can lead to cost escalation and inefficient resource use. The paper concludes with recommendations for hospital administrators, clinicians, and policy makers on designing governance structures, information systems, and multidisciplinary committees that systematically assess the value of endovascular technologies and align them with sustainable hospital financial strategies.

KEYWORDS: Endovascular therapy; Hospital financial management; Cost–benefit analysis; Cost-effectiveness; EVAR; Mechanical thrombectomy; Health economics; Capital budgeting; Reimbursement; Value-based care.

How to Cite: Sarah Leah Dsouza, Pooja Kapoor, Girija Paranjpe, Praveen P, Viral S Ahire, Amarnath Gupta, Meenakshi Duggal, (2025) Cost–Benefit Analysis Of Modern Endovascular Technologies In Hospital Financial Management, Vascular and Endovascular Review, Vol.8, No.12s, 191-198.

INTRODUCTION

The increasing adoption of modern endovascular technologies has reshaped clinical practice in vascular, cardiovascular, and neurointerventional medicine, prompting hospitals to reassess how these innovations affect financial performance and long-term sustainability. Procedures such as endovascular aneurysm repair (EVAR and TEVAR), drug-eluting stent implantation, mechanical thrombectomy, and emerging techniques like endovascular renal denervation are known to improve patient outcomes by reducing procedural morbidity, hospital length of stay, and recovery time. However, these clinical advantages come with substantial capital investment, expensive consumable devices, increased staff specialization requirements, and evolving reimbursement pathways. As a result, hospitals are under pressure to determine whether these technologies produce measurable financial benefits relative to their costs. A structured cost–benefit analysis (CBA) framework has therefore become essential for aligning technological adoption with hospital-level financial management strategies.

Since 2010, research examining the economic implications of endovascular therapies has demonstrated varied findings based on procedure type, reimbursement model, and evaluation perspective. Early health economic evaluations of drug-eluting stents by Schaffer et al. (2011) revealed that although these stents had higher upfront procedural costs than bare-metal stents, they significantly reduced repeat interventions, creating long-term economic value. Suh et al. (2013) supported these findings, showing that long-term cost savings emerged only when analyses extended beyond the first treatment year, highlighting the importance of multi-year budget considerations. Despite these findings, both studies focused on payer-based outcomes rather than hospital-specific financial returns.

Economic evaluations of EVAR present another complex picture. Burgers et al. (2016) reported that EVAR can be cost-effective across a lifetime horizon due to reduced intensive care and recovery expenditures, despite the high device cost. Dolatshahi et al. (2020) extended this analysis, concluding that EVAR is more cost-effective in high surgical risk groups but financially uncertain in low-risk patients. In contrast, Gupta et al. (2020) observed that EVAR procedures still generated higher inpatient costs than open repair, mainly due to expensive implants. More recent studies, including Kang et al. (2021) and Mehta et al. (2024), further demonstrated that reimbursement structures and follow-up imaging requirements critically influence whether EVAR offers financial returns at the hospital level.

In neurovascular care, mechanical thrombectomy has consistently demonstrated favourable economic outcomes. Aronsson et al. (2016) and Kunz et al. (2020) showed that thrombectomy is highly cost-effective due to reduced disability, improved functional outcomes, and decreased long-term rehabilitation expenditures. Subsequent evaluations by van den Berg et al. (2022), Rattanavipapong et al. (2022), Schwarting et al. (2024), and Han et al. (2024) confirmed that thrombectomy yields strong economic value across diverse health systems and patient populations. Yet, similar to EVAR research, these studies largely adopt societal or payer perspectives rather than examining direct operational costs, staffing burdens, and reimbursement constraints faced by hospitals.

The most recent literature also highlights emerging technologies such as renal denervation. Taylor et al. (2024) reported that the procedure may be cost-effective when compared to lifelong unmanaged hypertension complications; however, hospital-specific financial evidence remains limited. Micro-costing analyses of elective endovascular aneurysm procedures and coil embolization studies further reveal that device procurement and single-use consumables dominate total procedural costs, making supply chain negotiation a critical financial determinant.

Overall, research from 2010 to 2024 demonstrates consistent clinical advantages and encouraging long-term cost-effectiveness trends for many endovascular procedures. However, the majority of studies focus on payer or societal frameworks rather than hospital financial models. Critical gaps remain in evaluating capital depreciation, procedural volume thresholds, staffing economics, reimbursement variability, and opportunity costs associated with operating theatre and hybrid suite utilization. Therefore, there is a growing need for hospital-level cost–benefit models that account for real operational environments and financial constraints. This study responds to that need by developing an applied framework to assess the financial feasibility of adopting modern endovascular technologies within hospital systems, enabling strategic decision-making that balances innovation with fiscal responsibility.

MODERN ENDOVASCULAR TECHNOLOGIES: CLINICAL AND ECONOMIC CONTEXT

Modern endovascular technologies have transformed the landscape of vascular intervention by shifting treatment pathways from open surgical procedures to minimally invasive, device-driven techniques. These innovations—such as drug-eluting stents, endovascular aneurysm repair (EVAR), coil embolization systems, thrombectomy devices, atherectomy catheters, intravascular imaging, and robotic-assisted navigation—have significantly improved clinical outcomes, reduced procedural risks, and enhanced patient recovery timelines. The clinical impact of these technologies aligns with evolving healthcare priorities focused on efficiency, safety, and long-term therapeutic efficacy.

Clinically, endovascular procedures are associated with reduced perioperative morbidity, shorter hospital stays, and decreased need for general anesthesia compared to conventional surgery. For example, EVAR has become a preferred therapy for abdominal aortic aneurysm (AAA) in eligible patients due to lower mortality risk and faster recovery, although long-term follow-up and reintervention costs remain considerations. Similarly, mechanical thrombectomy devices in stroke management and drug-coated balloons (DCBs) in peripheral arterial disease (PAD) have demonstrated improved vessel patency, reduced restenosis rates, and better functional outcomes. Advanced imaging tools such as intravascular ultrasound (IVUS) and optical coherence tomography (OCT) further optimize treatment precision, allowing real-time assessment and tailored device deployment, supporting evidence-based decision-making and improved procedural success rates.

Alongside clinical advantages, the economic implications of endovascular technologies are increasingly relevant within hospital financial management frameworks. High acquisition and device costs often present initial financial barriers for healthcare institutions. These include procurement expenses, specialized training, dedicated hybrid operating suites, and maintenance of digital navigation and imaging platforms. However, cost-benefit analysis reveals that despite initial investment, long-term financial gains may be realized through operational efficiencies, reduced intensive care utilization, faster patient turnover, and avoidance of high-cost postoperative complications.

Moreover, reimbursement models globally are increasingly adapting to support minimally invasive interventions due to demonstrated value in reducing readmission rates and improving patient satisfaction metrics. Health systems that apply value-based care frameworks view endovascular solutions as cost-saving strategies over time, especially when factoring patient quality of life, workforce productivity, and reduced disability costs. Technologies with proven long-term durability and lower reintervention requirements hold superior economic value and are increasingly prioritized in procurement strategies.

Hospitals integrating advanced endovascular technologies must also consider implementation cost dynamics such as negotiated vendor contracts, lifecycle cost analysis, and technology-based clinical governance models. Strategic investment planning, supported by cost–effectiveness studies and health technology assessment (HTA) methodologies, allows hospital administrators to determine whether the technology aligns with institutional service demand and patient population needs.

In summary, modern endovascular technologies offer substantial clinical benefits while presenting complex economic considerations. Their adoption reflects a balance between upfront expenditure and long-term value generation driven by improved efficiency, clinical excellence, and alignment with precision-based healthcare delivery models. Through structured cost–benefit analysis, hospitals can optimize adoption strategies, ensuring sustainable implementation that enhances both patient outcomes and financial performance.

COST COMPONENTS IN ENDOVASCULAR TECHNOLOGIES

Endovascular technologies have transformed vascular and cardiovascular care by offering minimally invasive treatment alternatives to open surgery. However, despite their clinical advantages, these technologies involve multiple cost components that significantly influence hospital financial strategies and reimbursement planning. A detailed cost–benefit analysis requires understanding both direct and indirect expenditures incurred across procurement, infrastructure, and operational phases.

The first major cost category is device-related expenses, which typically represent the highest proportion of total endovascular procedure costs. These include consumables such as stents, balloons, drug-eluting devices, catheters, guidewires, embolization coils, grafts, and closure systems. Specialized devices like drug-coated balloons or custom fenestrated grafts significantly increase expenditure compared to conventional devices. Hospitals must balance device selection with evidence-based outcomes and reimbursement frameworks.

Another essential cost component involves capital investment and infrastructure, including imaging systems (angiography suites, fluoroscopy units, hybrid operating rooms), surgical navigation software, sterile handling equipment, and associated maintenance contracts. Hybrid operating theatres, though costly, support multi-specialty procedures and reduce surgical time and postoperative complications, potentially generating long-term financial benefits.

Human resource and procedural costs also contribute significantly. Skilled personnel such as interventional radiologists, vascular surgeons, anesthesiologists, nurses, and technologists require continuous training to keep pace with rapidly evolving technology. Simulation-based training tools and certification programs incur additional expenses but enhance safety and procedural efficiency. Postoperative care costs, including ICU monitoring, pharmacotherapy (e.g., anticoagulants, antiplatelets), imaging follow-ups, and outpatient rehabilitation, may vary depending on patient complexity and procedure type. Endovascular approaches often reduce hospital stay duration and readmission rates, providing a cost advantage over open surgery.

Indirect cost variables include supply chain logistics, sterilization, device storage, regulatory compliance, and waste management. Multi-vendor procurement frameworks, bulk purchasing agreements, and reimbursement optimization strategies help hospitals reduce operational expenditure.

Despite high initial costs, endovascular technologies often produce long-term savings through reduced morbidity, shorter hospital stays, lower complication rates, and improved patient throughput. Therefore, comprehensive financial evaluation requires integrating cost data with clinical outcomes, patient quality-adjusted life years (QALYs), and long-term survival metrics.

Table 1: Major Cost Components in Endovascular Technologies

Cost Category	Examples	Cost Impact Level	Notes
Device Costs	Stents, balloons, catheters, grafts	High	Largest share of per-procedure cost
Capital Investment	Imaging systems, hybrid OR, navigation systems	Very High	Long-term investment with amortization
Human Resources & Training	Surgeon fees, staff training, simulation programs	Moderate to High	Essential for safety and skill retention
Procedural Consumables	Contrast agents, anesthesia, sterile kits	Moderate	Usage varies per case
Postoperative Care	ICU stay, medications, follow-up imaging	Low to Moderate	Lower compared to open surgery
Logistics & Maintenance	Sterilization, storage, warranty, quality compliance	Low	Indirect but unavoidable

BENEFITS FROM THE HOSPITAL PERSPECTIVE

The integration of modern endovascular technologies into vascular and cardiovascular services offers multiple strategic and financial advantages for hospitals, particularly those operating in competitive healthcare markets. From a financial management standpoint, the cost–benefit analysis demonstrates that although initial investments in advanced endovascular systems—such as drug-eluting stents, robotic endovascular systems, intravascular ultrasound (IVUS), and hybrid operating suites—may be high, the long-term returns are substantial through operational efficiency, improved patient throughput, and reduced post-operative costs.

One of the primary benefits is the reduction in inpatient length of stay. Minimally invasive endovascular procedures result in shorter recovery periods, fewer complications, and reduced need for intensive postoperative monitoring. This leads to improved bed turnover rates, enabling hospitals to treat more patients without requiring additional infrastructure expansion. Increased case volume also strengthens hospital financial performance, particularly in settings where reimbursement models reward high-quality, efficient care.

Additionally, modern endovascular technologies improve clinical outcomes, which directly correlates with enhanced hospital reputation and accreditation scoring. Improved patient outcomes translate into lower readmission penalties and better clinical performance indicators—an increasingly important metric for insurance-based reimbursements under value-based healthcare systems. High patient satisfaction further enhances institutional branding, making the hospital a preferred choice for referral pathways from primary care and regional clinics.

Advanced endovascular platforms also support strategic workforce optimization. Precision tools reduce the procedural time per case, allowing surgeons and multidisciplinary care teams to operate more efficiently. The automation and digital integration capabilities of contemporary systems, such as AI-assisted imaging and data-driven intraoperative guidance, reduce human error and enhance training efficiency for new clinicians.

From an asset management perspective, modern endovascular equipment often has longer usability cycles and modular upgrade capabilities. This reduces future replacement costs and allows hospitals to phase financial planning over several years rather than making frequent capital purchases. Moreover, modern systems enable diversification of service offerings—including advanced limb salvage, neurovascular intervention, and complex aortic repair—expanding the hospital's revenue streams.

Finally, endovascular interventions reduce downstream costs linked to open surgical complications, prolonged rehabilitation, and repeated interventions. When evaluated over a five- to ten-year financial horizon, hospitals benefit significantly from improved clinical efficiency, expanded procedural capabilities, higher patient throughput, and strengthened financial sustainability. Thus, from a hospital management perspective, adopting modern endovascular technologies is not only a clinical advancement but a strategic investment in long-term operational success.

Table 2: Cost–Benefit Summary from Hospital Perspective

Category	Short-Term Cost Impact	Long-Term Financial Benefit
Technology Acquisition (IVUS, Hybrid OR, Robotic Systems)	High capital expenditure	Increased procedural capacity and extended service portfolio
Workforce Training & Adaptation	Moderate operational cost	Reduced procedural time and improved clinical efficiency
Procedure Time & Resource Use	Decrease in consumables variability	Higher throughput and efficient resource utilization
Inpatient Length of Stay	Reduced hospitalization costs	Increased bed turnover and patient capacity
Clinical Outcomes & Readmissions	Improved outcomes lower penalties	Higher reimbursement and better institutional ranking
Maintenance & Upgrades	Moderate recurring cost	Extended equipment lifecycle and modular upgrades

METHODOLOGICAL APPROACHES TO COST–BENEFIT ANALYSIS

Cost–Benefit Analysis (CBA) plays a critical role in evaluating the financial viability and clinical value of modern endovascular technologies within hospital management frameworks. Given the rising costs associated with devices such as flow diverters, drug-eluting stents, mechanical thrombectomy systems, and robotic angiography platforms, hospitals must employ rigorous methodological approaches to ensure that investments align with patient outcomes, resource utilization, and long-term sustainability.

A robust methodological approach to CBA begins with defining the scope and objectives, including identifying the targeted patient population, clinical indications, and expected measurable outcomes. Hospitals must distinguish between direct costs, such as device procurement, consumables, maintenance, and clinician training, and indirect costs, including operating room scheduling, staffing patterns, and workflow adjustments. Additionally, intangible benefits—improved patient satisfaction, reduced clinician fatigue, and enhanced institutional reputation—should also be accounted for, although their valuation may require expert consensus or proxy indicators.

The next methodological step is baseline establishment and comparators. This may involve comparing endovascular technologies with traditional surgical treatments or previously used devices. Historical case reporting, clinical trial data, and institutional benchmarks support the creation of a realistic baseline against which financial and clinical projections are measured.

Quantitative modeling methods, such as Net Present Value (NPV), Return on Investment (ROI), and Incremental Cost-Effectiveness Ratio (ICER), enable financial teams to incorporate lifetime cost reductions resulting from shorter hospital stays, reduced complication rates, and minimized readmission risks. Longitudinal modeling also supports the estimation of future cost trends, particularly where consumables and licensing fees apply.

To complement quantitative analysis, sensitivity and scenario testing evaluate model resilience under varying conditions—such as fluctuating device costs, reimbursement policies, or patient volumes. Monte-Carlo simulations, threshold analysis, and break-even projections further refine decision support, particularly where uncertainty is high or data availability is evolving.

Finally, integration with hospital financial management systems ensures that CBA outcomes are aligned with budgeting cycles, procurement pathways, and reimbursement structures. The results of a well-structured CBA provide decision-makers with a transparent, evidence-based foundation for purchasing strategies, resource optimization, and sustainable clinical growth.

Table 3: Components of Methodological Approaches to CBA in Endovascular Technologies

Methodological Component	Description	Example Application
Scope Definition	Establishes objectives, stakeholders, and clinical purpose	Adoption of robotic angiography system for neurovascular cases
Cost Identification	Includes direct, indirect, and intangible cost factors	Device cost, staff training, workflow modification
Baseline & Comparator Selection	Determines alternatives for comparison	Open surgery vs. percutaneous stent placement
Quantitative Modeling	Uses ROI, NPV, ICER, and cost-utility metrics	NPV over 5-year device lifecycle
Sensitivity & Scenario Analysis	Tests model robustness against uncertainty	Varying reimbursement and patient volume
Implementation Integration	Aligns analysis with hospital financial policy	Budget planning and procurement approval

CHALLENGES IN APPLYING CBA TO ENDOVASCULAR TECHNOLOGIES

Conducting a cost–benefit analysis (CBA) for modern endovascular technologies presents several methodological, financial, and clinical challenges that make evaluation complex within hospital financial management systems. One of the primary barriers is the high initial acquisition and maintenance cost of endovascular equipment, including angiography suites, imaging systems, and single-use catheters. These costs vary across manufacturers and regions, making it difficult to establish a standardized cost baseline. Additionally, endovascular procedures often require hybrid operating rooms and technically skilled staff, further complicating cost allocation across departments.

Another major challenge involves accurately calculating benefits, particularly when benefits are long-term or intangible. Endovascular treatments, such as EVAR for aortic aneurysms or drug-eluting stent placement, may reduce hospital readmission, postoperative complications, and mortality. However, quantifying these outcomes in monetary terms requires long-term patient follow-up and reliable outcome databases—resources that many hospitals lack. Furthermore, benefits such as improved patient quality of life, reduced pain, faster recovery, and earlier return to work fall under indirect or intangible benefits, which are difficult to measure using standard financial metrics.

Variation in clinical outcomes presents another challenge. Endovascular technologies evolve rapidly, with frequent upgrades and device innovations. This pace of innovation can render previous cost-effectiveness data obsolete, making longitudinal CBA difficult. Clinical variability based on surgeon skill level, patient anatomy, comorbidities, and postoperative care also influences outcomes and cost estimates, limiting the generalizability of CBA findings.

Reimbursement models also complicate CBA. In many health systems, reimbursement for endovascular procedures may not fully reflect procedural complexity or consumables cost, leading to discrepancies between financial expenditure and institutional revenue. Hospitals must balance clinical demand, regulatory compliance, and reimbursement uncertainties when interpreting CBA results.

Data limitations further weaken CBA accuracy. Many institutions struggle to capture real-time cost data, including consumables, labor hours, imaging utilization, and complication-related costs. Without robust informatics integration, the analysis may rely on estimations rather than precise costing.

Finally, ethical considerations may influence cost-based decision-making. Applying strict CBA may risk limiting access to advanced technologies for high-risk or elderly patients whose projected economic benefits appear lower, despite clear clinical need.

Overall, CBA for endovascular technologies requires a multidisciplinary, dynamic, and data-driven approach. Despite its challenges, refining CBA frameworks can help hospitals optimize investment decisions, improve patient care outcomes, and ensure long-term financial sustainability.

IMPLICATIONS FOR HOSPITAL FINANCIAL MANAGEMENT

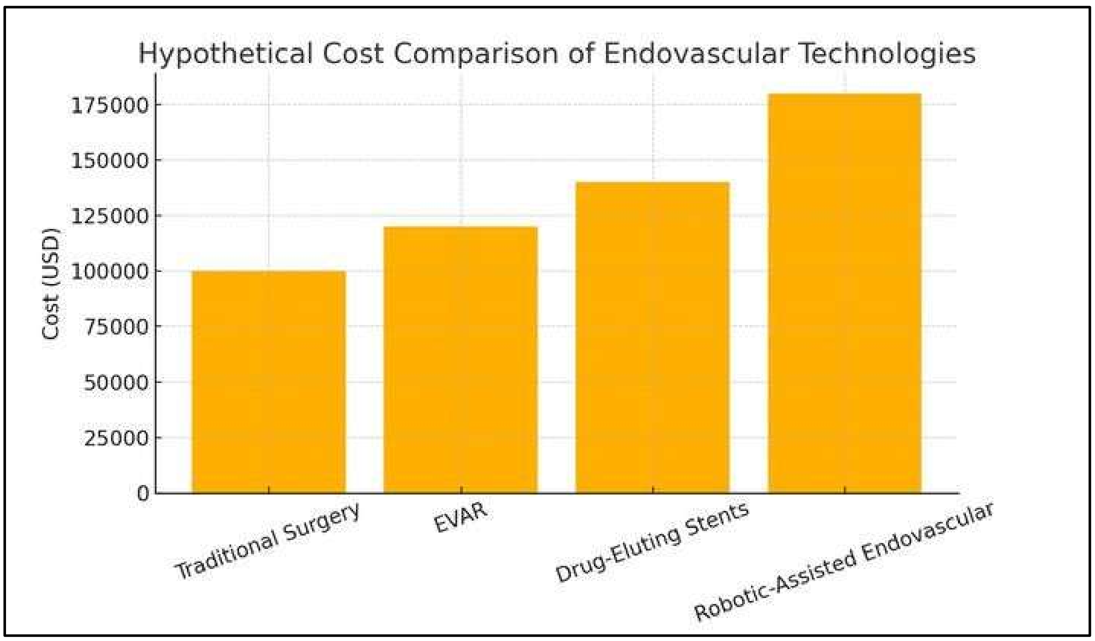
The cost–benefit analysis of modern endovascular technologies has significant implications for hospital financial management, particularly as health systems transition toward value-based care. Endovascular procedures, despite being capital-intensive and requiring advanced imaging systems, robotic assistance platforms, and consumable devices, offer long-term financial benefits when evaluated through outcome-driven and efficiency-based lenses. From a budget allocation perspective, hospitals must balance high initial acquisition and training expenses with projected downstream savings derived from reduced surgical complications, shorter patient hospital stays, and decreased readmission rates.

Strategic procurement planning becomes essential, requiring hospitals to adopt evidence-based investment decisions supported by clinical performance data, vendor negotiation strategies, and utilization forecasting. The increased procedural efficiency associated with minimally invasive endovascular interventions enables higher patient throughput, improving operational capacity and revenue generation under both fee-for-service and bundled payment models. Additionally, reduced length of stay directly influences bed turnover and operating room scheduling optimization, further improving institutional resource utilization.

Financial risk assessment and cost modelling frameworks are also reshaped, particularly as payers increasingly evaluate reimbursement based on patient outcomes, safety indicators, and total cost of care. Hospitals must incorporate analytical tools, such as return-on-investment (ROI) projections and cost-utility analyses, to determine how new devices and technologies align with reimbursement policies and clinical priorities.

Finally, capacity-building investments in workforce training and interdisciplinary clinical governance are critical to sustain financial gains. Skilled vascular specialists and trained support teams enable optimal device utilization, reducing procedural waste and complication-related costs. Thus, the financial implications extend beyond procurement and directly influence quality improvement, strategic growth, and long-term competitiveness in endovascular services.

Fig 1: Hypothetical Cost Comparison of Endovascular Technologies



CONCLUSION

Modern endovascular technologies represent a central pillar of contemporary vascular and cardiovascular care, offering substantial clinical benefits to patients. For hospitals, however, they are both an opportunity and a challenge. High device and infrastructure costs, combined with variable reimbursement and evolving practice patterns, demand rigorous financial evaluation. Cost–benefit analysis, when integrated with complementary health economic methods and supported by robust data systems, provides hospital decision-makers with a powerful tool to assess the value of these technologies.

Rather than simply asking whether a device is “expensive,” hospitals must consider whether it is expensive relative to the benefits it delivers—for patients, for the institution’s financial health, and for the broader goals of the health system. Endovascular technologies can indeed be financially sustainable and even advantageous when introduced strategically: in the right patients, at sufficient volume, with appropriate infrastructure, and under governance structures that prioritise value. Conversely, indiscriminate adoption without careful evaluation risks cost escalation and misallocation of scarce resources.

Ultimately, aligning clinical innovation with sound financial management is essential for hospitals seeking to deliver high-quality, technologically advanced care while maintaining long-term viability. Systematic application of cost–benefit analysis to modern endovascular technologies is a critical step toward achieving that balance.

REFERENCES

1. Satpathy, Abhilash, et al. "To study the sustainable development practices in business and food industry." *Migration*

Letters 21.S1 (2024): 743-747.

2. George, Bibin, et al. "Impact of Digital Libraries on English Language Academic Writing." *Library of Progress-Library Science, Information Technology & Computer* 44.3 (2024).
3. Shami, Shifa, et al. "Impact Of English Language Learning On Mental Health: Exploring The Relationships Between Language Anxiety, Self-Esteem, And Depression." *Journal of Neonatal Surgery* 14.9s (2025).
4. Sridevi, T., et al. "Impact Of English on The Cross-Cultural Information Flow in Digital Libraries." *Library of Progress-Library Science, Information Technology & Computer* 44.3 (2024).
5. Shami, Shifa, et al. "Impact Of English Language Learning On Mental Health: Exploring The Relationships Between Language Anxiety, Self-Esteem, And Depression." Journal of Neonatal Surgery 14.9s (2025).
6. Vanisree, M., et al. "Role of English Language in Digital Library Instruction and Information Literacy." Library of Progress-Library Science, Information Technology & Computer 44.3 (2024).
7. Sunalini, K. K., et al. "Role of English Language in Facilitating Interdisciplinary Learning in Higher Education." Library of Progress-Library Science, Information Technology & Computer 44.3 (2024).
8. Riad, M. J. A., Debnath, R., Shuvo, M. R., Ayrin, F. J., Hasan, N., Tamanna, A. A., & Roy, P. (2024, December). Fine-Tuning Large Language Models for Sentiment Classification of AI-Related Tweets. In *2024 IEEE International Women in Engineering (WIE) Conference on Electrical and Computer Engineering (WIECON-ECE)* (pp. 186-191). IEEE.
9. Riad, M. J. A., Roy, P., Shuvo, M. R., Hasan, N., Das, S., Ayrin, F. J., ... & Rahman, M. M. (2025, January). Fine-Tuning Large Language Models for Regional Dialect Comprehended Question answering in Bangla. In *2025 IEEE International Students' Conference on Electrical, Electronics and Computer Science (SCEECS)* (pp. 1-6). IEEE.
10. Sultana, S., Akuthota, V., Subarna, J., Fuad, M. M., Riad, M. J. A., Islam, M. S., ... & Ashraf, M. S. (2025, June). Multi-Vision LVMs Model Ensemble for Gold Jewelry Authenticity Verification. In *2025 International Conference on Computing Technologies (ICOCT)* (pp. 1-6). IEEE.
11. Ashraf, M. S., Akuthota, V., Prapty, F. T., Sultana, S., Riad, J. A., Ghosh, C. R., ... & Anwar, A. S. (2025, April). Hybrid Q-Learning with VLMs Reasoning Features. In *2025 3rd International Conference on Artificial Intelligence and Machine Learning Applications Theme: Healthcare and Internet of Things (AIMLA)* (pp. 1-6). IEEE.
12. Shuvo, M. R., Debnath, R., Hasan, N., Nazara, R., Rahman, F. N., Riad, M. J. A., & Roy, P. (2025, February). Exploring Religions and Cross-Cultural Sensitivities in Conversational AI. In *2025 International Conference on Artificial Intelligence and Data Engineering (AIDE)* (pp. 629-636). IEEE.
13. Fnu, H., Soni, V., Asundi, S., Thummarakoti, S., Kaushik, K., & Soni, M. (2025, May). Design and Deployment of AI-Driven Fraud Detection Models in Cloud-Based Banking Ecosystems. In *2025 International Conference on Networks and Cryptology (NETCRYPT)* (pp. 223-228). IEEE.
14. Fnu, H., & Murri, S. (2025, April). Algorithmic Approach for Fraudulent Transaction Detection using Market Basket Analysis with Big Data. In *2025 4th International Conference on Distributed Computing and Electrical Circuits and Electronics (ICDCECE)* (pp. 1-7). IEEE.
15. Fnu, H., Kaushik, K., Gaur, P., Saratchandran, D. V., Thapliyal, A. G., Sidhu, K. S., & Singh, V. (2025, April). Multi-Agent Systems for Collaborative Financial Decision-Making Over Distributed Network Architectures. In *2025 3rd International Conference on Advancement in Computation & Computer Technologies (InCACCT)* (pp. 939-944). IEEE.
16. Murri, S., Fnu, H., Kumawat, R., Pujari, T. D., Kaushik, K., & Arora, A. S. (2025, April). Federated Machine Learning for Decentralized Financial Data Analysis in Cloud Environments. In *2025 4th OPJU International Technology Conference (OTCON) on Smart Computing for Innovation and Advancement in Industry 5.0* (pp. 1-7). IEEE.
17. Borra, C. R., Cheekati, S., Pareek, P. K., Rayala, R. V., Kothuri, S. R., & Kumar, S. V. (2025, May). An Intelligent IoT Attack Detection Model Using Weighted ELM and Educational Achievement Guided Optimization. In *2025 13th International Conference on Smart Grid (icSmartGrid)* (pp. 789-796). IEEE. **(15)**
18. Cheekati, S., Rayala, R. V., & Borra, C. R. (2025, February). A Scalable Framework for Attack Detection: SWIM Transformer with Feature Optimization and Class Balancing. In *2025 3rd International Conference on Integrated Circuits and Communication Systems (ICICACS)* (pp. 1-7). IEEE.(**10**)
19. Cheekati, S., Borra, C. R., Kumar, S., Rayala, R. V., Sangula, S. K., & Kulkarni, V. (2025, May). Intelligent Cybersecurity for IoT: A Hybrid QRIME-SDPN Approach for Network Attack Detection on CIC-IoT-2023. In *2025 13th International Conference on Smart Grid (icSmartGrid)* (pp. 774-781). IEEE**.(20)**
20. Cheekati, S., Borra, C. R., Pareek, P. K., Rayala, R. V., Kowsalya, S. S. N., & Selvam, J. (2025, May). Cybersecurity Threat Detection Using OpCyNet and DBRA: A Deep Learning Approach for DDoS Attack Mitigation on CICDDoS2019. In *2025 13th International Conference on Smart Grid (icSmartGrid)* (pp. 782-788). IEEE.**(17)**
21. Rayala, R. V., Borra, C. R., Pareek, P. K., & Cheekati, S. (2024, November). Enhancing Cybersecurity in Modern Networks: A Low-Complexity NIDS Framework using Lightweight SRNN Model Tuned with Coot and Lion Swarm Algorithms. In *2024 International Conference on Recent Advances in Science and Engineering Technology (ICRASET)* (pp. 1-8). IEEE. (**23**)
22. Rayala, R. V., Borra, C. R., Pareek, P. K., & Cheekati, S. (2024, November). Fortifying Smart City IoT Networks: A Deep Learning-Based Attack Detection Framework with Optimized Feature Selection Using MGS-ROA. In *2024 International Conference on Recent Advances in Science and Engineering Technology (ICRASET)* (pp. 1-8). IEEE.(**20**)
23. Rayala, R. V., Borra, C. R., Pareek, P. K., & Cheekati, S. (2024, November). Hybrid Optimized Intrusion Detection System Using Auto-Encoder and Extreme Learning Machine for Enhanced Network Security. In *2024 International Conference on Recent Advances in Science and Engineering Technology (ICRASET)* (pp. 1-7). IEEE.**(19)**
24. Rayala, R. V., Borra, C. R., Pareek, P. K., & Cheekati, S. (2024, November). Securing IoT Environments from Botnets: An Advanced Intrusion Detection Framework Using TJO-Based Feature Selection an d Tree Growth Algorithm-Enhanced LSTM. In *2024 International Conference on Recent Advances in Science and Engineering Technology (ICRASET)* (pp. 1-8). IEEE**.(15)**

25. Rayala, R. V., Borra, C. R., Pareek, P. K., & Cheekati, S. (2024, November). Mitigating Cyber Threats in WSNs: An Enhanced DBN-Based Approach with Data Balancing via SMOTE-Tomek and Sparrow Search Optimization. In *2024 International Conference on Recent Advances in Science and Engineering Technology (ICRASET)* (pp. 1-8). IEEE**.(18)**
26. Borra, C. R., Rayala, R. V., Pareek, P. K., & Cheekati, S. (2025, May). Optimizing Security in Satellite-Integrated IoT Networks: A Hybrid Deep Learning Approach for Intrusion Detection with JBOA and NOA. In *2025 International Conference on Intelligent and Cloud Computing (ICoICC)* (pp. 1-8). IEEE.(**13**)
27. Borra, C. R., Rayala, R. V., Pareek, P. K., & Cheekati, S. (2025, May). Advancing IoT Security with Temporal-Based Swin Transformer and LSTM: A Hybrid Model for Balanced and Accurate Intrusion Detection. In *2025 International Conference on Intelligent and Cloud Computing (ICoICC)* (pp. 1-7). IEEE.(**4**)
28. Borra, C. R., Rayala, R. V., Khan, Z., & Cheekati, S. (2025, May). Optimized Intrusion Detection for IoT Networks Using Machine Learning and Feature Selection with RTGBO-ELM Integration. In *2025 International Conference on Intelligent and Cloud Computing (ICoICC)* (pp. 1-6). IEEE.(**5**)
29. Borra, C. R., Rayala, R. V., Khan, Z., & Cheekati, S. (2025, May). Enhancing IoT Network Security: Machine Learning-Based Intrusion Detection Using Vortex Search Optimization and SMOTE for Improved Classification. In *2025 International Conference on Intelligent and Cloud Computing (ICoICC)* (pp. 1-7). IEEE.(**10**)
30. Borra, C. R., Rayala, R. V., Khan, Z., & Cheekati, S. (2025, May). Intrusion Detection in IoT Networks: Leveraging RNN with Quantum-Based Hummingbird Optimization for Enhanced Classification Accuracy. In *2025 International Conference on Intelligent and Cloud Computing (ICoICC)* (pp. 1-6). IEEE.(**11**).
31. Sunalini, K. K., et al. "Role of English Language in Facilitating Interdisciplinary Learning in Higher Education." *Library of Progress-Library Science, Information Technology & Computer* 44.3 (2024).
32. Yusupova, Shirinoy. "Advantages of artificial intelligence in teaching english." *Academic research in educational sciences* 4.CSPU Conference 1 (2023): 468-474.