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MINIMALLY INVASIVE SPINE SURGERY (W HSU, SECTION EDITOR)

Economic Value in Minimally Invasive Spine Surgery

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Abstract

Purpose of Review The field of spine surgery remains a unique target in the transition to value-based care. While spine surgery has benefited from new medical technologies, including minimally invasive surgery (MIS), these technologies may be a key driver in rising US healthcare costs. As such, MIS needs to clear an economic value threshold through a rigorous evaluation of the outcomes they provide and costs they incur. In this article, we review recent MIS surgery literature from the perspective of economic value.

Recent Findings Many studies report modest all-in cost savings and direct procedural cost equivalence for minimally invasive approaches relative to open surgeries. In terms of quality, studies found lower blood loss, length of stay, and infectious complications with MIS surgery but evidence on QALYs was mixed.

Summary In the past 5 years, there has been increasing research interest in defining economic value in MIS surgery. However, a significant amount of heterogeneity in research quality and methodology persists. Therefore, MIS surgery has the potential to be of high economic value, though this is not yet definitive. Future research should continue to focus on high-quality cost-effectiveness studies with clear methodologies to further elucidate economic value in MIS surgery.

Keywords Health economics · Cost-effectiveness · QALYs · Quality · PROMIS · Procedure cost

Introduction

The total health expenditures of the USA currently account for over 17% of the nation's gross domestic product and continue to grow at an alarming trajectory [1]. Value-based care has been cited as a potential solution for mounting healthcare costs. The Patient Protection and Affordable Care Act (2010), through the Center for Medicare and Medicaid Services (CMS), has instituted numerous changes, including payment reform, that affect the economics and practice of spine surgery [2–4]. Historically, Medicare reimbursement has been built on a fee-for-service financial model. While most payments continue to retain a fee-for-service architecture today, initiatives, such as the Bundled Payments for Care Improvement (BPCI) through the CMS Center for Medicare and Medicaid Innovation, aim to lower cost and improve quality, thus increasing the value of the care provided [5].

The introduction of value-based reimbursement and increased use of reportable metrics have prompted surgeons to search for best practices that improve patient outcomes and encourage efficient resource allocation [6, 7]. Total direct healthcare costs for patients with a spine condition rose from $132 billion in 1996–1998 to $253 billion in 2009–2011, representing an increase of 91% [8]. Furthermore, with an aging population continuing to drive higher demand and disproportionate growth of minimally invasive spine (MIS) surgery, the field of spine surgery remains a unique target in the transition to value-based care [9–11]. While spine surgery has benefited from new medical technologies, including minimally invasive surgery, these technologies may be a key driver in rising US healthcare costs [12]. As such, MIS procedures and spine surgery, at large, need to clear an economic value threshold through a rigorous evaluation of the outcomes they provide and costs they incur. In this article, we

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review recent MIS surgery literature from the perspective of economic value.

Defining and Measuring Economic Value

While different healthcare stakeholders have variations on the definition of economic value, for the purposes of this review, it will be defined as outcomes relative to the cost of the intervention [13, 14]. The numerator of the value equation, outcomes, cannot be measured by any single measure. The denominator of the value equation, cost, is an aggregate cost of the intervention, not the cost of each individual service. The value equation is maximized when outcomes are durable over time and recurrent costs are low.

Economic value is typically measured using cost-effectiveness analyses (CEA). Currently, these types of studies are relatively uncommon in the spine literature and have significant variability in their methodologies [15, 16]. The current acceptable threshold for cost-effectiveness (cost/quality-adjusted life year gained) is not exactly defined but ranges between $50,000 and $100,000 [15, 17]. The US Panel on Cost-Effectiveness in Health Medicine has set forth a set of recommendations to guide CEA design, including definitions of cost depending on perspective, discounting of cost to account for the time value of money, and methodology for sensitivity analyses [18]. Consistent methodology and reporting of outcome measures and costs included in CEAs will be crucial for future spine studies looking to evaluate the economic value of MIS surgeries relative to open procedures.

Measuring Quality and Cost

In spine surgery, there are a variety of methods to evaluate patient outcomes and quality of care. A number of validated, legacy measures exist for evaluating general health (SF-36, EQ-5D) and spine-centric (Neck Disability Index, Oswestry Disability Index) outcomes [19]. In addition, reportable metrics, based on mortality, post-operative complications, readmissions, process scores, and patient satisfaction scores, continue to be utilized as markers of quality [20]. Over the last 5 years, there has been an important development in the measurement of quality with the advent of patient-reported outcomes (PROs). In particular, the validation of the Patient-Reported Outcomes Measurement Information (PROMIS) for cervical and lumbar spine surgery has been significant due to its incorporation of patient preference [21, 22]. Nearly all of these legacy and PROs measures allow for reliable and validated conversion to quality-adjusted life years (QALY) [23, 24]. While no comprehensive measure of outcomes or quality currently exists, QALYs allow for the quantification of various health states on a single scale for the purpose of CEA and comparison across different interventions. It is important to recognize that QALYs assume homogenous provider skill level and that all patients have the same utility for a given health state [25].

Defining the denominator of the economic value equation is equally challenging. There is a lack of consistency in the selection of costs to include in CEA across the spine literature [15]. Studies often utilize charge data to calculate cost-effectiveness ratios, leading to an overestimation of costs and underestimation of economic value. [15] The multicenter Spine Patient Outcomes Research Trial (SPORT) trial has identified components of cost, including a breakdown of direct (healthcare visits, diagnostic tests, medications, surgery) and indirect (productivity loss, etc.) costs [26•]. Future spine CEAs must strive to clearly define their methodologies for quality and cost.

Methods for Literature Review

We conducted a PUBMED/Medline search for all articles using key terms: “minimally invasive spine cost,” “minimally invasive spine cost-effectiveness,” and “minimally invasive spine value.” A total of 395 articles were found from the above key terms. Articles were manually reviewed for relevance. Articles were excluded if they (1) were in a language other than English, (2) were non-human or cadaveric studies, (3) had no reference to spinal procedures, and (4) had no description of cost data and/or value associated with MIS procedures. A total of 58 articles ended up meeting the inclusion and exclusion criteria.

Economic Value in MIS Spine

Cost Data

Cost data was reported from a wide array of perspectives. Initially, literature suggested that minimally invasive approaches tended to have higher costs associated with newer technologies, equipment, and increased operating room times due to the relatively high learning curve [15, 27–31]. Subsequently, minimally invasive approaches were thought to decrease costs indirectly, offsetting the increase in initial direct costs [15, 27–31]. Although considerable variability exists in reported costs of minimally invasive procedures, recent studies actually suggest that direct costs associated with minimally invasive surgery may have decreased. Recent cost analysis studies have shown that the direct procedural costs of minimally invasive approaches mirror those of open approaches; some studies even report modest savings in direct procedural costs. [32–37] In fact, all studies within our literature review reported some degree of total cost savings, albeit variable. Short-term all-in cost savings noted in all papers ranged broadly from $2825 per patient through $37,775 per patient [38–42].

Within our search, the most commonly published topic (7 studies) was the cost-effectiveness of open versus minimally invasive Transforaminal Lumbar Interbody Fusion (TLIF) procedures. Of these 7 articles, all noted significant cost savings [32–37] or cost equivalence [43•] associated with minimally invasive TLIF compared with open TLIF. The reported total costs savings ranged from $8731 to $9295 [32–37]. Similarly, direct hospital costs were noted to be lower in the minimally invasive groups than in open groups, with reported direct cost savings ranging from $1758 to $2820 per patient [32–37]. Parker et al. estimated indirect costs associated with increased risk of surgical site infections for open procedures and reported an indirect costs savings of $98,974 per patient by performing minimally invasive rather than open TLIFs [44]. Awad et al. reported no difference in outcomes for minimally invasive TLIFs when choosing to instrument with unilateral as opposed to bilateral screws, all the while noting a direct cost savings of roughly 35% when instrumenting only unilaterally [16].

Similarly, minimally invasive approaches for scoliosis surgery have gained traction as both safe and cost-reducing. Two articles compared the use of minimally invasive approaches and open approaches in scoliosis correction surgery, both noting similar outcomes between the two groups and significant cost savings in the minimally invasive group (ranging from $25,868 to $122,082) [45•, 46]. Mansfield et al. compared costs associated with single-level anterior cervical discectomy and fusion versus minimally invasive cervical posterior fusion and found the minimally invasive option was associated with an average of 89% cost reduction, mostly attributable to lower operating room and supply costs [47]. Furthermore, MIS surgery has been noted to be cost-saving or cost-equivalent to non-operative care for patients requiring treatment for sacroiliitis, with the majority of savings resulting from indirect costs and inconvenience over time [48–51]. Three articles compared costs associated with interspinous spacers with minimally invasive surgery for spinal stenosis patients. All noted minimally invasive surgery to be widely more cost-effective [26, 34, 52]. On the other hand, Menger et al. further compared minimally invasive surgery for spinal stenosis with robotic surgery, noting robotic surgery to have shorter operating times as well as better screw placement, resulting in long-term indirect savings in the range of $314,661 per patient as a result of a lower associated need for future revisions [53]. Furthermore, Maillard et al. suggests that techniques in minimally invasive spine surgery have improved to the extent that they should be employed in more complex procedures whenever possible, such as trauma or fractures, in order to cut costs and reduce hospital length of stay [54].

Quality Data

Numerous studies reporting quality data associated with minimally invasive surgery were identified, with the majority of articles focusing on lower complication rates and lower hospital length of stay [27, 36••, 37, 41, 46, 54•, 55]. Estimated blood loss was unanimously reported as lower in all relevant studies [27, 37, 41, 46, 56]. Similarly, lower incidence of surgical site infections were also noted [44]. Evidence concerning QALYs was mixed, however. While the majority of studies reported an increase in QALYs associated with minimally invasive approaches as compared with similar open approaches, other studies reported equivocal QALY scores, especially as time since surgery increased [33, 39, 57–59]. Increases in reported QALYs associated with minimally invasive approaches over open procedures ranged dramatically, from 0.06 QALYS for scoliosis to 0.73 QALYs for sacroiliitis [45, 60]. Additionally, despite numerous cost savings reported from using minimally invasive approaches over interspinous spacers for spinal stenosis, Parker et al. failed to note any increase in QALYs over spacer use [34].

Conclusion

In the past 5 years, there has been increasing research interest in defining economic value in MIS surgery. However, a significant amount of heterogeneity in research quality and methodology persists. Many studies report modest all-in cost savings and direct procedural cost equivalence for minimally invasive approaches relative to open surgeries. These results are subject to significant cost methodology variability. In terms of quality, studies found lower estimated blood loss and infectious complications with MIS surgery but evidence on QALYs was mixed. Therefore, MIS surgery has the potential to be of high economic value, though this is not yet definitive. Future research should continue to focus on high-quality cost-effectiveness studies with clear methodologies to further elucidate economic value in MIS surgery.

Compliance with Ethical Standards

Conflict of Interest Benjamin Hopkins BS, Aditya Mazmudar BA, and Kartik Kesavabhotla MD declare no conflict of interest. Alpesh A Patel MD declares royalties from Amedica, Nuvasive, Zimmer, stock ownership in Amedica, Nocimed, Vital 5, Cytonics, consulting for Amedica, Relievant, Pacira, Nuvasive, Zimmer, and service on the Board of Directors of CSRS.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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