



The Hidden Pandemic: the Cost of Postoperative Complications

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Abstract

Purpose of Review Population-based increases in ageing and medical co-morbidities are expected to substantially increase the incidence of expensive postoperative complications. This threatens the sustainability of essential surgical care, with negative impacts on patients' health and wellbeing.

Recent Findings Identification of key high-risk areas, and implementation of proven cost-effective strategies to manage both outcome and cost across the end-to-end journey of the surgical episode of care, is clearly feasible. However, good programme design and formal cost-effectiveness analysis is critical to identify, and implement, true high value change.

Summary Both outcome and cost need to be a high priority for both fundholders and clinicians in perioperative care, with the focus for both groups on delivering high-quality care, which in itself, is the key to good cost management.

Keywords Surgery · Perioperative medicine · Economics · Complications · Cost-effectiveness

Introduction

Postoperative complications place a significant burden on the health and wellbeing of patients and families and health-care systems. In an era of an increasing healthcare demand and financial challenges, delivery of high-value perioperative care becomes essential to ensure healthcare sustainability. It is therefore timely to review the scale of the issue, the actual and projected costs, and the potential cost–benefit of change and how it might be driven.

The Hidden Pandemic

Surgery is essential to manage a high proportion of healthcare demands and must expand to meet future need [1]. The current resource requirements for surgery and perioperative care are usually well understood by most institutions, but the emerging issue of postoperative complications and their sequelae need to be well appreciated for forward planning.

Firstly, we know significant postoperative complications are already common and occur in around 20% of patients [2–6], although the reported incidence may depend on detection methods used [7]. Secondly, insight into those at risk is provided by national outcome databases [8, 9] and data from large multi-centre trials [10–12]. Derived risk assessment tools can provide good information on the risk of (costly) complications to guide clinical practice and system performance analysis [13–15], with refinements such as frailty assessment potentially enhancing their predictive ability [16]. These tools have limitations for some surgeries or when attempting to predict individual risk [17, 18] but, nonetheless, can be used effectively to assist early patient triage, discussions with consumers, and risk-adjusted institutional performances [19–21]. Thirdly, we expect risk factors to become more frequent, especially those which are age-related. In Australia, it is predicted that, by 2047, the number of people aged between 65 and 74 years will grow by 150%, 75–85 years by 220%, and > 85 years by 300% [22]. Organisation for Economic Co-operation and Development (OECD) countries are expected to experience similar increases. For example, the percentage of the population aged > 75 years in the USA is predicted to increase from 6.7% in 2018 to 9.7% by 2030, and those aged > 85 years from 2% in 2018 to 2.6% by 2030 [23]. The overall OECD economic burden of ageing can be, in part, gauged by the 'old age dependency ratio' (proportion of those > 64 years

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and those 15–64 years), estimated for the USA to change from 0.245 to 0.334 in the same period [24].

Such shifts will have major impacts on budgets, including those for healthcare. The overall burden on postoperative complications is uncertain but is speculated to increase by 10% annually based on age alone [25]. Illness burden is likely to also increase. Taking obesity alone, 58% of adults were overweight or obese in 2017 across 23 OECD countries [26]. Its prevalence worldwide has almost doubled since 1980, although the rate of increase may be declining. Obesity is itself sometimes described as a pandemic [27]. It has an accompanying health burden and has been estimated to have contributed to 7% of all deaths in 2015 and 5% of disability adjusted life years. Obesity and its associated comorbidities are well represented in most perioperative risk tools.

The impact of the more visible pandemic, COVID-19, is as yet uncertain. The vulnerability of the elderly to COVID-19 is clear, and projected population increases may not be reached for some countries. Whether COVID infection increases the incidence of chronic disease states is not well known. It is likely there will be a temporary increase in the demand for medical and surgical care because of delayed screening for diseases such as cancer [28], and there will be a backlog of surgery, estimated recently at 28 million surgical cases worldwide [29].

The future scale of increases in perioperative risk is hard to accurately predict, but all indicators suggest it may increase substantially. Hence, the term pandemic, one applied to diseases such as obesity and cancer, seems justified. It is relatively hidden, but projections suggest it should be a high priority for healthcare funders and providers.

The Cost of Complications

Complications come at a cost, financial and otherwise, to a range of stakeholders. What is measured, and how, then becomes critical to the cost-outcome to be considered. When examined in clinical trials, study design is relevant. There are relatively few randomised controlled trials (RCTs), although the contribution of observational studies, in particular because of feasibility, cost, and external validity, should not be overlooked [30].

Trial endpoints need to be carefully chosen. Reporting of implicit cost analysis from easily measured internal hospital sources will have limited external validity [21]. In contrast, explicit cost–benefit or cost-effectiveness analysis including micro-costings, in- and out-of-hospital-costs, and quality-adjusted life years (QALY), and accompanied by explicit analysis and calculation of uncertainty, can provide very useful information across jurisdictions [31••].

A recent quality assurance paper, although not directly addressing surgery, provides detail on elements needed,

sources of data, and study design for strong economic analysis. It highlights the need for comprehensive cost analysis: “...the value of each resource consumed needs to be estimated to obtain an estimate of healthcare payer-borne costs.” [32].

The Nature of Costs

Most data on perioperative complications and costs are provided from the perspective of the hospital, where data collection is relatively easy and directly relevant to those providing surgical and perioperative care. Less often reported are out-of-hospital events and costs which may or may not be relevant to hospital budgets. Reported less often again are indirect consumer and societal costs, such as quality of recovery and dependence on care from family or friends, or inability to work [33••]. The broader issue of opportunity costs, or on what else could healthcare costs be spent if costs of preventable complications were minimised, is a matter more often considered by economists, healthcare funders, or policy makers. The availability of hospital cost data therefore provides the majority of that considered in this review, but reference to other costs is also discussed, as available.

The Measured Costs of Complications

Individual studies of hospital-focussed complications and costs are plentiful. For example, a study from the Netherlands on complications after abdominal surgery showed that costs doubled for minor complications and doubled again for major complications [34]. This included detailed in-hospital costs, but not out-of-hospital costs, or re-admissions, which may add substantially to cost [35].

These data align with an earlier study of 1200 patients having elective abdominal surgery, with over half the cases having at least one complication, and with costs increasing over twofold as a result. Again, costs were closely aligned with complication severity, with average cost increases going from \$3000 to \$130,000 as Clavien-Dindo grade increased [36]. This mirrored an Australian study of colonic resection, with Clavien-Dindo grade I–IV complications increasing costs by 15.8%, 36.8%, 169.4%, and 240.1%, respectively. This study accounted for detailed elements of in-hospital care, including costs for the operating room, ICU, and investigations, and some early out-of-hospital care relevant to hospital budgets [37]. A similar New Zealand study also found a doubling of costs with complications, but a less marked association with complication severity [38]. Systematic reviews for liver and rectal surgery also support this relationship between cost and complications, and cost and complication severity, but considerable study heterogeneity,

and presumably the contextual nature of cost, limits the financial conclusions which can be drawn [39, 40].

Detailed in-hospital costs provide insight into where attention may be best directed. For example, in a small single centre study, 75% of the costs of major complications related to initial hospitalisation, with the most costly elements being room and board, re-operation, and ICU, with 20% of the costs from re-admissions [41].

Sustainability of care from the providers' perspective relates not just to costs, but also to reimbursement. Hospital costs and their implications for budgets was the subject of a single centre analysis of detailed costs, reimbursement, and complications for surgical episodes across a range of casemix. Costs, reimbursement, and profit margin varied substantially across the procedures [42••]. Cost increases associated with complications ranged from around 25% to 175%, with the largest being for complicated cholecystectomy, taking the costs from approximately \$9000 to \$24,000. Profits depended on the balance of procedure and complication and the structure of reimbursement loadings. Only colectomy remained profitable in cases with complications. When broken down across surgeries, the sometimes perverse relationship between costs and reimbursement was apparent. All individual complications had a negative effect on profit, but organ space surgical site infection (SSI) almost tripled hospital profit. Overall, complications reduced an average profit margin of almost 6% to break-even, although private funding maintained strong profits whereas publicly funded cases generated a loss. Such data are increasingly relevant to both funders and healthcare providers. As the authors concluded, with a shift to prospective payments, "...there is a need to understand the magnitude of those risks for different procedures." Out-of-hospital costs were not specified and thus impacts on community burden and costs are unknown.

Responses to these types of data should include an improved focus on complication prevention: "the study.... supports all efforts to lower negative events in the postoperative course." However, alternate unhelpful behaviours, such as case selection and 'cream skimming' or 'cherry picking' to avoid risk, may arise, and are discussed later.

A large study of Medicare payments for older patients undergoing a range of surgeries between 2009 and 2012 [43] found mean overall complication rates from 4.9% for total hip replacement to 25.1% for colectomy. Separating patients with complications with successful rescue (no mortality) revealed that Medicare payments (rather than costs) were consistently 50% greater for those with complications, with costs for re-admissions and post-acute care accounting for a high proportion of increases. Of note, substantial variability in the cost of rescue across institutions was identified, with associations identified between these costs and outcomes—price may not always reflect quality. The authors' conclusion that "These results highlight the potential for hospitals to

examine strategies for managing perioperative complications to identify opportunities for improved cost efficiency with surgery." emphasises the potential benefits to sustainability of a quality focus on care.

The relationship between individual complications, their incidence, and cost, sheds some light on where improved investment in quality may most benefit cost. Data from the UK for 2016–2017 show a high incidence of SSIs, with the cumulative incidence ranging from 9.2% in large bowel surgery to < 1% in clean surgery such as knee prosthesis [44]. Similar data from the Veteran Affairs system in the USA show a significant burden from SSI infections, each with substantial cost [45]. The absolute costs of surgery-specific hospital acquired infection (HAIs) for the UK was not provided, but HAIs overall are estimated to cost the NHS £1–2 billion a year, mostly as inpatient costs.

A retrospective analysis of NSQIP-derived data from 6000 patients for 30 days after surgery in 2016 across a range of casemix provides further detail on specific complications [46]. The most common complications were ileus and anastomotic leak (incidence of 18.5% and 4.5%, respectively). Costs were estimated for specific medical complications and processes and included detail down to pharmacy costs and post-discharge encounters. The most expensive adjusted complications were prolonged ventilation (\$48,000) and unplanned intubation (\$26,000). Deep or organ space SSI, anastomotic leak, and ileus were all similarly costly at around \$10,000–\$12,000. Processes (re-admission, and re-operation) were intermediate, at around \$8000 and \$20,000, respectively. Preventable complications are relevant. For example, postoperative ileus, to some degree preventable through a range of strategies, cost over \$10,000 per case, with an incidence of almost 20% and increased LOS [47]. High compliance with early recovery after surgery (ERAS) elements has been associated with a 30% decrease in the risk of ileus, suggesting direct ERAS benefits to not only patients, but also healthcare sustainability [48]. Equally, the incidence of SSI may respond to bundles of care. For example, a small before and after study, whilst not finding a statistically significant decrease in infections, did find a significant decrease in (costly) re-admissions [49]. Re-admissions may reflect well the consequences of overall reduced complications rates and costs [35] as do derived parameters such as days-at-home after surgery (DAH) [50••].

Longer Term Costs

Delayed complications may also be highly relevant to costs, but are less well acknowledged, in part because of their temporal separation from surgery. Their potential impact is highlighted in a cohort study of elderly patients undergoing non-cardiac surgery examining costs out to 1 year [51••].

Delirium-attributed cost increases of around 30% were calculated in most time periods from in-hospital stay out to 12 months. The derivation of delirium-attributed costs is not detailed, and precise separation from medical co-morbidities costs may be hard to determine. However, assuming an incidence of delirium of 25% for older surgical patients, the authors estimate delirium-related costs postoperatively in the USA at \$33 billion annually, even not accounting for consumer and community non-health costs. What proportion is preventable is uncertain, but these data emphasise that delayed sequelae after surgery clearly warrant attention in adverse event reporting, and in future trials, if whole of health high value care is to be determined.

Another aspect of this is evident from 2000 data on the impact of postoperative out-of-hospital care strategies on outcome and cost after joint replacement [52]. The authors stated: "...the use of rehabilitation hospitals may lower readmission rates, but at a prohibitive incremental cost of each saved readmission, that patients discharged with home care had longer acute care stays than other patients, that the provision of home care services increased health system costs, and that acute care readmission rates were greatest among patients discharged with home care. Our study should be seen as one important stepping stone towards a full economic evaluation of the continuum of care for patients." Twenty years later, many studies on the cost of complications, or on high value care, still risk reporting biased or incomplete economic analyses.

Patient-reported experiences (PROMS), especially those occurring after discharge, are relevant to determining overall care quality and cost. Measures such as QALYs require patient-relevant outcomes and are important to guide health sector priority setting [53]. It has been suggested that "the debate is not primarily why or if we should measure PROMs, but rather how, when and what to measure, and how to interpret the results." [54]. PROMS have been analysed for range of surgeries, with evidence of longer-term benefit in some cases [55–57]. Explicit translation into overall cost–benefit is less common.

Study design is important for this dimension of cost and benefit. A small study of knee arthroplasty found positive overall QALY benefits, and the authors concluded: "PROMs can be used in economic evaluation to help measure the value and quality of orthopaedic surgery" [58]. They also showed that imperfect timing of QALY could bias economic conclusions. If nothing else, PROMS provides an opportunity to improve the quality of reporting of conventional complications [59] or to enhance clinical screening for emerging complications [60].

It is hoped that these endpoints will be used more frequently in the future, such as in a current study of a recovery after cancer surgery which specifically examines how complications influence PROMS [61]. A systematic review

of PROMS after abdominal surgery concluded: "There is very limited evidence supporting the measurement properties of existing PROMs used in the context of recovery after abdominal surgery. This precludes the use of these PROMs to support value-based surgical care. Further research is required to bridge this major knowledge gap." [62].

Evidence of Benefit

In contrast to the volume of data on specific postoperative complications and to a degree cost, high-quality studies incorporating formal and detailed cost–benefit or cost-effectiveness techniques are uncommon.

In the case of new technology, such as robotic surgery, studies showing modest benefits are frequent, and they rarely include the investment required, such as capital purchase, maintenance, and training [63, 64]. As stated some years ago "As the use of robotic technology in colon surgery continues to evolve, critical appraisal of the benefits offered in comparison with the resources consumed is required." [65].

In practice, it can be challenging to prove benefit from individual perioperative practice changes when are just one element in a complex end-to-end system of care [66]. Examination of the cost and outcome benefits of systems changes may be more fruitful, but is less common. Further, methods for formal cost–benefit or cost-effectiveness analysis are well described, and utilised in decisions on purchase of technology such as new cancer drugs, but also less commonly used in perioperative analysis [53].

What constitutes good economic analysis in surgery and perioperative care has been outlined well and focuses on (i) the outcome to be included (cost versus benefit, consequences and effectiveness) and (ii) the perspective of the analyser (hospital, community, and consumer). The author's conclusion that "The focus of the decision-maker dictates which costs and benefits to include" may explain the predominance of studies of hospital-based costs and outcomes [67••].

In systems change, there have been large number of recent studies examining cost and benefit from enhanced recovery pathways (ERPs) [68]. A recent systematic review found absolute cost reductions ranged from \$1500 to \$7000 for colorectal surgery, for example, although statistical significance was uncommon. Of note, only one study included out of hospital costs, and major changes in the incidence of in-hospital complications were not clearly related to cost savings [69••]. An umbrella review examined 23 manuscripts and concluded that ERAS programmes can reduce LOS and costs (averages of 2.4 days and \$639, respectively) [70]. How well ERP is adopted appears critical to benefit. A recent observational study of ERAS hospitals found moderate compliance with ERP

elements, some improvements in complications, and a relationship between compliance and outcome [71]. This relationship aligns with other evidence of improving outcomes after ERP implementation [72, 73••]. Hence, investment in programmes to encourage and monitor compliance is logical but needs to be incorporated into cost analyses of benefit. Implementation delays are concerning and relevant to mechanisms to drive change—see later.

It is notable that, in some ERP studies, complications associated with substantial sequelae, and cost, such as acute kidney injury, anastomotic breakdown, and SSI, were not necessarily improved. Hence, translation into cost benefits and return on investment is not necessarily demonstrated. A before and after study of complications and costs did attribute a \$7129/patient reduction in direct cost as likely to be due to a decrease in complication rate. It is relevant that, although statistically significantly reduced rates of complications were limited, this did include SSIs, known to be a high-cost complication. Whilst the cost savings were higher than those reported elsewhere, there were not substantial statistically significant decreases in in-hospital complications [74]. Re-admission costs are not included or specified in a number of studies, although those that did reported substantial cost decreases [75, 76]. Re-admissions, or the days-at-home after surgery, are strongly associated with decreases in in-hospital complications [35] and may be impacted by enhanced postoperative care [77]. Further, in funding systems which penalise re-admissions, this can have a large impact on institutional costs, as well as out-of-hospital resource utilisation.

Reduced LOS is reported in many outcome and cost studies, but optimal LOS is a fine balance between avoidance of excessive stay and potentially ‘rushed’ discharge with downstream sequelae [78]. In addition, reduced LOS may not always have a major impact on hospital cost. Hospital daily costs are not linear, with ‘hotel costs’ predominating in the days just prior to discharge [79, 80]. Despite this, and depending on institutional funding and missions, ‘opportunity costs’ must also be considered. Reduced LOS may allow hospitals in systems with uncapped volume to receive additional revenue from other activities. In systems with capped surgical volume, added capacity may be used to generate cost savings and reassign funds to other healthcare or non-healthcare areas.

It is re-admissions, rather than LOS, which have been “... identified by the Medicare Payment Advisory Commission as a major action item for some time, ...hospital readmissions remain prevalent, costly, and largely preventable.” “The goal of the CMS’s strategy is to effect a 20% reduction in hospital readmission rates by the end of 2013, thereby potentially preventing 1.6 million hospitalizations and saving an estimated \$15 billion.” [81]. Certainly, inclusion of

re-admission, or days-at-home, should be strongly considered in all studies addressing the cost of complications.

Combining analysis of systems change with formal economic analysis is more uncommon again. It has been applied to a pathway of extended thromboprophylaxis, a study which considered a healthcare system perspective on benefit and cost [82]. It has also been used to examine post-discharge impacts and costs after colorectal surgery associated with ERPs [31••]. Data collection included patient input, with measurement of delayed endpoints such as lost days from work, requirement for help with activities of daily living, caregiver lost days from work, and postoperative visits to community, surgical, and family medicine services. There were benefits in lost days from work for patients or caregivers and time for community health visits. Cost analysis showed benefits in terms of out-of-pocket expenses of around \$1400 and almost \$3000 in terms of overall societal costs. “ERPs did not shift the burden of care from the inpatient to outpatient setting, as ERPs were associated with faster return to work and reduced caregiver burden.”

Formal cost-effectiveness analysis might be considered the economic gold standard if true value is to be calculated in addressing postoperative complications and should be encouraged in trials design.

Institution of Cost Management

Whilst evidence of the cost of complications alone should drive change, in practice, this can be challenging. For example, slow uptake and imperfect compliance with ERP processes is measurable and relevant to outcome and cost improvement [48, 73••, 83]. Drivers at payer and institutional levels may encourage more rapid institution of high quality, if quality is associated with cost-effectiveness (to the institution) [84]. Competition in the marketplace, coupled with prospective (bundled) payments to providers, provides one mechanism to address costs. Retrospective payments (such as fee for service) provide little control of volume of activity, and hence costs, leaving insurers or payers holding the risk of excessive costs [85].

The move towards prospective payments, such as Diagnostic Related Group (DRG)-based funding, with fixed or bundled payments, transfers the financial risk of excessively costly care (such as treatment regimens with increased risk of complications) to healthcare providers. Institutions and clinicians are increasingly incentivised to address costs: “Under bundled payment plans, (financial) risks are accepted through combining payments for hospitals, physicians, and post-acute care services...” [42••]. This mechanism’s effect on costs is further enhanced if yardstick competition is applied, whereby, across similar hospitals, price for activity is set to average observed costs and re-adjusted regularly.

This yardstick approach improves costs efficiencies over time, assuming a sufficient sample obtains meaningful averages and that assuming: “The regulator (will)...not pay attention to the firms complaints and to be prepared to let firms go bankrupt” [86]. It is logical this will enhance a focus on costly elements of perioperative and surgical care delivery and especially mechanisms to reduce costly complications discussed previously. There is a risk such mechanisms encourage undesirable responses such as upcoding to maximise provider returns [87, 88••], case selection (“cream skimming”), collusion, skimming, or laying off costs to others [89, 90]. Concerns around skimming are often voiced by clinicians. The counter to this is to apply the thinking around quality of Michael Porter who stated some years ago that “...achieving and maintaining good health is inherently less costly than dealing with poor health.” [91].

A recent review of Medicare bundled prospective payments designed to improve on the “incentive to increase volume that is inherent in traditional fee-for-service payment”, reduce cost of care, and at least not worsen quality, provides data on the effect of such mechanisms [92••]. A very brief summary of their conclusions is that costs for only some conditions are reduced, hospital production costs have decreased (which holds promise for the potential of yardstick mechanisms), quality has generally not improved, and some gaming has arisen. Whilst not an overwhelming endorsement of the theories discussed here, it does suggest that this approach, perhaps with the addition of specific imposed constraints, may offer solutions for the future.

Whether this approach addresses quality is less clear [93], despite economic modelling suggesting specific quality-improving funding measures can be effective [94••]. Hence, additional regulatory or incentivisation mechanisms may also be needed at an institutional level. For example, national standards on compliance with best practice, such as avoidable re-admissions, linked to institutional accreditation and financial acknowledgement of avoidance of re-admission after surgery may encourage best practice and cost reduction [95, 96]. Obviously, selection and monitoring of standards is essential to obtain benefit.

Conclusions

Based on the predicted increased need for surgical care, the increased risk of costly postoperative complications in many countries, and increasing economic challenges in funding healthcare, there is an imperative to identify and deliver high value care to minimise both complications and cost. This needs a comprehensive approach, with high-quality data on cost and outcome, which encompasses the entire perioperative journey, which focusses on quality, and which is accompanied by robust cost-effectiveness analysis.

This task is challenging, involving a wide range of stakeholders and interests. The priority, and challenges, of this topic were acknowledged at a recent national summit in Australia involving experts from multiple stakeholder groups [20]. Whilst there were no quick fixes identified, the principles and recommendations at least start to provide a framework for generating high value perioperative care to start to address costly postoperative complications. Frameworks such as this, combined with studies designed to deliver high-quality evidence on cost and benefit of effectiveness, should be a priority to meet our populations’ surgical needs into the future.

Declarations

Conflict of Interest The author does not have any potential conflicts of interest to disclose.

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