Robotic cholecystectomy: A cost comparison with historically novel laparoscopic cholecystectomy

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Abstract

Introduction

Robotic cholecystectomy (RC) is an emerging modality in minimally invasive surgery. Critics of this technology however cite unsubstantiated costs in a fiscally tight health care budget as a major limitation to widespread use. Laparoscopic cholecystectomy (LC) was also once an “emerging” technology which shared similar critiques yet is now considered standard of care for gallbladder disease. In order to assess the merit of cost critiques, we performed a retrospective analysis for historically “novel” LC and compared with the modern equivalent, RC.

Materials and methods

Using a PubMed database search, an operating room cost differential was calculated for LC vs. open cholecystectomy (OC). Similarly a modern operating cost-differential was calculated for RC vs. LC. Both values were inflation adjusted to the current US dollar value using the Consumer Price Index (CPI) for Medical Care Specific Inflation, (fiscal year 2012).

Results

After standardizing cost, the modern added cost of each “emerging” technology was +$904 for LC, compared with +$1164 for RC.

Discussion

As an emerging technology, LC was once regarded as experimental and costly but is now recognized as the gold standard for benign gallbladder disease. Robotic surgery is an example of a modern emerging technology equivalent that has shown merit for several minimally invasive procedures. If we use history as a guide, the additional cost associated with robotic surgery as a developing technology will diminish over time as market competition and utilization increases.

Conclusion

As robotic surgery is further developed and utilized there is a potential for the attenuation of cost similar to laparoscopic cholecystectomy. This potential is particularly true as patents expire and the market is opened to competition.

Introduction

Robotic surgery is becoming an increasingly utilized modality in minimally invasive surgery despite numerous reports debating the benefits of the technology. As is common with new technology, robotic surgery carries a high price tag and additional costs must be considered when integrating into a clinical practice. In the surgical community, critics of robotic surgery cite the large startup cost, added operating cost, and as yet underdetermined patient benefits as reasons to forgo this advancing technology. Understandably with reported startup costs for the da Vinci Surgical System (Intuitive Surgical, Sunnyvale, CA) around $1,000,000 and annual service contracts adding an additional $100,000, the figure is quite large.

When addressing this added cost it helps to consider it in the context of other emerging technologies that have made a significant impact in surgery. Looking for a direct comparator of robotic surgery you would find a clear analogue in laparoscopic surgery in the late 20th century. At the time when laparoscopic surgery was an emerging technology it also required a significant investment in specialized equipment, added cost to the operation, and the benefits were debated. Because of these similarities, we performed a cost analysis based on the current US dollar for the historically “emerging” technology of laparoscopic surgery and the modern equivalent of robotic surgery. We chose a common general surgical procedure, cholecystectomy, to base our cost analysis on because a large proportion of the initial experience was gained performing this operation and comparative articles are ubiquitous in the literature.

Cholecystectomy therefore provides a readily analysed benchmark for comparison over generations of technological advancements in surgery.

Materials and methods

To determine the added cost associated with LC as an emerging technology a PubMed database search was conducted to identify articles that reported the cost of implementing the historically novel technology. Articles were reviewed for reports on the cost associated with initiating a laparoscopic surgical program as well as the operating room-specific cost differential per procedure for LC vs. OC.

From the literature review, the capital investment in equipment necessary to perform LC was established based on the year of publication of the report. Similarly, the per-procedure cost differential was based on the publication year.

To determine the cost differential for RC vs. LC, an institutional inquiry was conducted at our academic institution to establish the added per-case cost of RC as an emerging technology. Operating room cost breakdown is recorded for all cases performed at our institution and is frequently monitored for cost control measures. For the purpose of this study, our perioperative administrators were petitioned to

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analyse and report the operating room cost for all laparoscopic and robotic cholecystectomy performed at our institution. Operating room cost reports were narrowed to isolate reports from two surgeons because they included both LC and RC cases during the study timeframe and therefore allowed for the most direct comparison. Both surgeons are board certified general surgeons with fellowship training in minimally invasive surgery. From this record, reported operating room cost differentials were combined and an average per-case cost computed (Table 1). For the sake of this report we limited our analysis to multiport LC and RC.

For each novel platform, the additional cost of the emerging technology versus the relevant gold standard (LC vs. OC and RC vs. LC) was calculated. Historical costs associated with LC vs. OC were translated into the modern financial equivalent by adjusting for inflation to the current fiscal year. This was done using the Consumer Price Index (CPI) for Medical Care specific inflation to establish the estimated modern cost (fiscal year 2012). The CPI is a measure of the annual purchasing power of the US dollar and is reported by the United States Department of Labor, Bureau of Labor Statistics. The CPI is subdivided into eight major groups to account for the variable rate of inflation in different categories of consumer goods. Medical Care CPI is one of eight major groups and tracks medical-specific commodities. The Medical Care CPI is necessary to account for the historically more rapid rate of inflation for the general consumer dollar compared with the general consumer cost of living (Figure 1).

**Discussion**

As a historically emerging technology LC once fell under the scrutiny of the surgical community when compared with the gold standard, OC. When it was introduced, the new modality had a steep learning curve and increased operative time. Despite these drawbacks, LC was quickly noted to decrease hospital length of stay and overall hospital cost. With these recognized advantages LC gradually became the new gold standard of care in general surgery. As a technology however, laparoscopic surgery has inherent challenges. Visualization is reduced to a 2-dimensional image and camera control requires a surgical assistant resulting in a degree of discordance between the working instruments and the viewing image. Additionally, laparoscopic instruments are limited to 4 degrees of freedom and require the surgeon to physically create the additional 3 degrees of freedom to obtain the capabilities of open surgery. This puts a physical strain on the operating surgeon leading to stress and fatigue.

Robotic surgery is an example of a modern emerging technological equivalent. Similar to its technological predecessor, RC adds time and cost to the procedure over the current gold standard, LC. As with any new technology however, operative efficiency improves and the components become more affordable over time as the market matures. To briefly illustrate this point, if prices had remained stable over time LC would cost approximately $3253.61 per case today. Instead, modern LC averaged $594 per case or roughly 1/6 the reported costs in 1991. If we once again compare the two technologies, RC would actually be less expensive than LC ($1758 vs. $3253) in current health care dollars. We believe that much like laparoscopic surgery, the individual components of robotic surgery will become more cost effective as operating room efficiency improves and competitive pricing drives overall cost down. Further cost reduction will be seen after initial learning curve of the

**Results**

From our literature review, the historic capital cost required to initiate a laparoscopic surgical program was reported as $100,000 in 1992. The mean operating room-specific cost differential for LC vs. OC was $354.52, ($1,387.94 vs. $1,033.42) as reported in 1991.

In comparison the purchase price of a da Vinci Surgical System starts around $1 million. Mean operating room cost differential for RC vs. LC at our institution was reported as +$1164 ($1,758 vs. $594) (Table 1). Our costs are in line with other reports in the literature.

In order to perform a direct comparison, historical costs were adjusted using the Medical Care CPI to fiscal year 2012. Adjusting the cost differential between the two modalities to the current fiscal year, the additional cost of LC vs. OC was approximately +$903.55 compared with the current figure of +$1164 for RC vs. LC. When considered in the value of the current US dollar, the added cost difference between each “emerging” technology would be +$260.75 for RC vs. LC.

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Robotic surgery continues to progress and be technology evolves and robotic surgery where, as an emerging suite but the technical aspects of the upgrades it brings to the operating room is in stark contrast to laparoscopic surgery which involves a second set of hands. Robotic instruments have 7 degrees of freedom and the capability to control three separate instruments and the camera without requiring a second set of hands. Ultimately this technology may diminish surgeon fatigue and secondarily decrease overall costs by increasing case volume and extending a surgeon’s career. The comparison of robotic and laparoscopic surgery is difficult because the modalities are similar in terms of abdominal access and operative technique. Robotic surgery sets itself apart by the technology it drastically altered the operative technique. The benefits of these upgrades therefore may take years to realize. However, as the technology evolves and robotic surgery continues to progress and be widely accepted, it can be utilized for more complex surgical procedures. The influence of robotic surgery on these more complex procedures as in surgical oncology and head and neck surgery would allow more patients to be offered this emerging technology with significant benefit to clinical outcomes as seen in the early days of adopting LC. Robotic surgery is an emerging technology fast gaining acceptance for certain procedures. The limiting factor for almost any new technology is added cost and robotic surgery is no exception. However, as efficiency increases, learning curves are overcome and more complex procedures are performed, the cost difference should fall. Add in the potential market competition predicted by patent expirations and that differential should fall even further.

**Limitations**

Our study represents a limited retrospective analysis of historical cost figures and attempts to extrapolate to modern figures using widely accepted inflation charts. It cannot however be considered a direct comparison in cost because all reported figures are a small sample within a large market and inflation charts represent a calculated figure of estimates based on the projected inflation of the US dollar. It does however provide a general reference of the cost of emerging technologies in the operative suite and provide a historical context with which to regard current robotic technologies.

**Conclusion**

As robotic surgery is further developed and increasingly utilized, there is a potential for the attenuation of cost similar to laparoscopic cholecystectomy. This potential is particularly true as patents expire on the technology. Competition in the open market will likely further advance the technology and concurrently decrease cost.

**References**