Purchase Decisions Regarding 3D Laparoscopic Surgery: Comparative Costs of Robotic versus ENDOEYE FLEX 3D Laparoscopic Surgery

AVALON HEALTH ECONOMICS

A recent surgery trend has been the rapid increase in the use of robotic-assisted technology in minimally invasive laparoscopic surgery. From 2011 to 2015, the number of robotic-assisted colorectal surgeries increased 158%, with the proportion of all colorectal surgeries performed robotically increasing from 2.2% to 6.6% over the time period.[1] Similar rates of diffusion have been observed in other therapeutic applications where robotic-assisted surgery (RS) has emerged as an alternative to minimally invasive laparoscopic surgery (LS), including bariatric and gynecological surgeries.

The principal advantages of RS are assisted manipulation via the robot that offers enhanced degrees of freedom in motion and three-dimensional (3D) visualization. In spite of these perceived advantages, meta-analyses of multiple studies consistently have shown that the overall clinical outcomes of RS and LS are similar, with statistically similar rates of complications and hospital readmissions.[2] Similarities in outcomes are also evident within three therapeutic areas where RS and LS are commonly used—colorectal, bariatric and gynecology.[3-5]

Olympus's ENDOEYE FLEX 3D® is another technological advancement beyond 2D laparoscopic surgery. This novel high-definition 3D articulating videoscope provides enhanced depth perception without sacrificing a level visual horizon, offering significant advantages over standard 2D scopes.[6] By enhancing visualization and precision, the Olympus 3D imaging system facilitates faster and more precise execution of surgical procedures (e.g., dissection, suturing and grasping), shortening the learning curve for surgeons[6], which may result in improved surgical outcomes. The Olympus 3D imaging system has the potential to offer equivalence in benefits of robotic surgery, but without the tradeoffs in dexterity and tactile stimulation seen with robotic surgery and at a substantially lower cost.

The substantial costs of robotic surgery are well established, and there have been significant concerns if robotic surgery is "worth the investment" given that the clinical outcomes are comparable between the two approaches.[7-8] In general, the costs and charges associated with RS are significantly higher than the costs associated with LS. One of the main drivers of the cost differential is the substantial up-front capital costs associated with RS. The average acquisition costs of a Da Vinci® surgical system is between $1.3 and $2.4 million,[9] compared to approximately $160,000 for the Olympus 3D imaging platform. In addition, RS is associated with greater use of disposables (need for disposables for each robotic arm in every procedure), more operating room (OR) set-up and docking time, and substantially greater annual maintenance costs compared to the Olympus 3D system (Table 1).

Not taking the depreciation into account for RS or LS equipment, in the first year of adoption, RS costs are $3.48 million compared to only $170,000 for the Olympus 3D system; that is, in the first year of ownership the total costs of ownership of one Da Vinci robot are more than 20 times higher than the costs of one Olympus 3D imaging platform (Table 1 & Figure 1).[10]

Taking into account the depreciation of RS and LS equipment results in an even larger differential because the annual costs of disposables, labor, and maintenance remain constant and are substantial for RS. With depreciation, assuming a 5-year life span for RS and LS equipment, robot costs are $1.95 million compared to only $42,000 for the Olympus 3D imaging platform (that is, the total costs of ownership of one Da Vinci robot are more than 46 times higher than one Olympus 3D imaging solution). Considering costs on a per-case basis does not change the relative differential in costs (Table 1 & Figure 1).

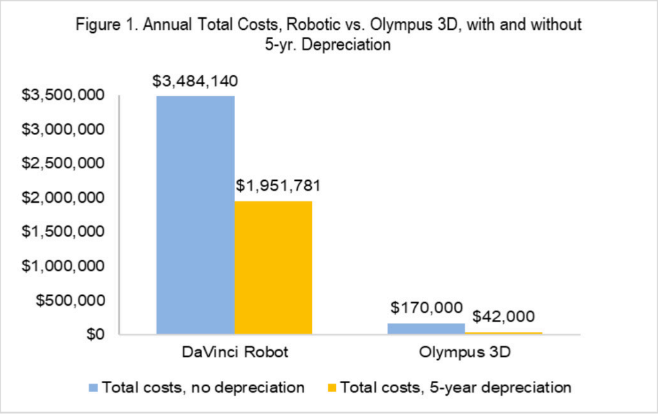
There are two other important factors affecting the total cost of ownership of RS. First, use of robotic equipment requires extensive training, but the vast majority of surgeons entering practice lack sufficient training. According to one study, 73% of general surgery fellows surveyed believed that their robotic surgery training was "poor or below average."[20] Consequently, the one-time training provided by the makers of Da Vinci systems may not be sufficient, and the cost estimates for additional training (shown in Table 1) are likely to be understated. Poor robotic training suggests that the "theoretical" efficiencies of robotic surgery are not likely to be achievable in practice.

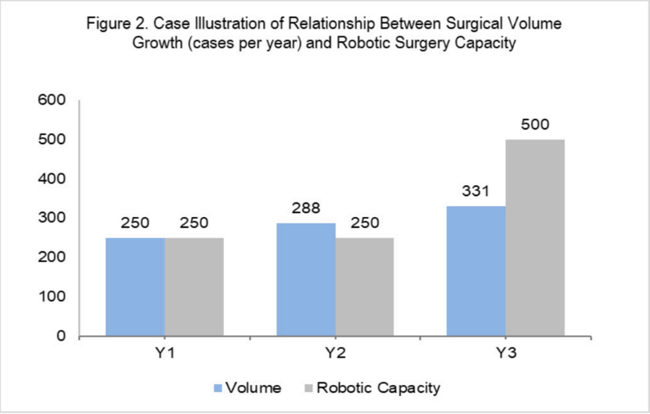
Indirect costs associated with robot "down time" should also be taken into account. Given the high capital costs, every hour of down time is associated with substantial costs. Assuming the potential for 2,000 available hours per year, the robotic equipment requires maintenance once every two weeks.[21] This means that 10% of the time (~200 hours), the robotics equipment is not available for use. This downtime means a loss of potential revenue and it does not eliminate the costs of acquiring the robotic system. Given the high capital costs ($1,915,448), the downtime equipment costs alone would be ~$1,000 per hour.

Table 1. Estimated Inflation-Adjusted[11] Annual Total and Per-Case Costs of Ownership: Da Vinci Robot vs. Olympus 3D Imaging Platform, 2017

	Da Vinci Robot		Olympus 3D Imaging Platform	
Cost Item	Per Case	Per Year	Per Case	Per Year
TCO for First Year of Operation, 2017				
Total capital cost (base per device) [a]	$7,662	$1,915,448	$640	$160,000 [f]
Disposables (per year) [b]	$2,137	$534,354	$0	$0
Labor (excluding procedure) [c]	$3,477	$869,315	$0	$0
Training costs [d]	$24	$6,000	$0	$0
Maintenance [e]	$636	$159,022	$40	$10,000
Total (1 year)	$13,937	$3,484,140	$680	$170,000
TCO for First Year of Operation, 2017, Assuming 5-Year Depreciation				
Total capital cost (base per device) [a]	$1,532	$383,090	$128	$32,000 [f]
Disposables (per year) [b]	$2,137	$534,354	$0	$0
Labor (excluding procedure) [c]	$3,477	$869,315	$0	$0
Training costs [d]	$24	$6,000	$0	$0
Maintenance [e]	$636	$159,022	$40	$10,000
Total (1 year; 5-yr. depreciation)	$7,807	$1,951,781	$168	$42,000

Notes & Sources: (a) Initial base cost per device;[9] (b) including only disposable costs unique to the device choice; based on 250 cases per year;[12] (c) based on operating room time associated with set-up, docking, and undocking; plus overhead (48.9 minutes @ 0.33/minute for personnel, plus 48.9 minutes @ $70.78/minute for operating room overhead results in $3,477 per case);[13-18] (d) costs associated with training one surgeon per year for six years after acquisition year (robotic capital costs including training of four surgeons in acquisition year);[19] (e) Maintenance costs produced from an average of two sources;[9] (f) approximate list price for Olympus 3D imaging platform.





Another important factor is "scalability" and the challenge that hospitals face in adjusting capacity to align with changes in volume over time. Consider the hypothetical case example shown in Figure 2, which depicts the total capacity of one or two robotic devices, relative to case volume changes over 3 time periods (e.g., years). At baseline (on the left), a hospital acquires one robot that serves the total volume of minimally invasive surgeries performed at the hospital in year 1, assumed to be 250 in this example. As overall surgery volume grows (assumed in this example to be 15% per year), assuming only a robot is available, the hospital has a shortfall in capacity in year 2 equal to 38 cases.

In response to the shortfall, the hospital adds a second robot that becomes operational in year 3. However, assuming ongoing volume growth of 15%, the hospital has now swung to having excess robotic surgery capacity equal to 169 cases. This disconnection between demand and capacity is likely to persist in future years, as managers find it difficult to align demand and capacity. In this case example, the misalignment problem actually worsens by year 3, and if volume were to continue to grow at the same pace, it would take another 3 years before robotic capacity was back in alignment with volume.

The "excess demand" in year 2 could easily be covered with the Olympus 3D imaging solution, which would provide the same level of quality at a fraction of the cost. The scenario shown in year 3 illustrates the problem of adding a second robot. In this scenario, nearly half of the capacity brought by the second robot results in very expensive excess capacity. With the Olympus 3D imaging platform, capacity alignment challenges are still at play, but the costs of addressing those challenges are of lower magnitude. In addition, the Olympus 3D imaging platform and the ENDOEYE FLEX 3D can be utilized in multiple surgical suites, which helps optimize capacity.

To summarize, in spite of the increase in enthusiasm for robotic-assisted minimally invasive surgery, there is no evidence that its use results in better outcomes when compared to standard 2D laparoscopy. The ENDOEYE FLEX 3D laparoscopic approach clearly offers improved visualization without compromising tactile feedback. However, the costs of the two 3D approaches, ENDOEYE FLEX 3D and DaVinci robotics are vastly different, regardless of the assumptions made in comparative analyses; even with full depreciation over the life span of the equipment, or per-case calculations over a large case volume, ENDOEYE FLEX 3D laparoscopic surgery may be a cost-effective solution as it is several orders of magnitude less expensive than robotic surgery. In addition, laparoscopic systems such as the Olympus 3D imaging platform are easily scalable to fit demand, avoiding the inevitable excess capacity caused by high capital costs associated with robotic equipment.

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Avalon Health Economics is a nationally recognized firm that provides high value real-world health economics and outcomes research consulting.

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[9] Average of two sources: (1) Amodeo A. et al. (2009). "Robotic laparoscopic surgery: cost and training. Minerva Urol Nefrol 61(2): 121-128. (2) Nayeemuddin, M. et al. (2013). Modifiable factors to decrease the cost of robotic-assisted procedures. AORN j 98(4): 343-352. Costs presented in table 1 have been adjusted for inflation according to the CPI index with an average taken with these 2 literature inputs.
[10] Capital cost estimates for robotic and Olympus 3D include the base equipment plus all necessary disposables and maintenance required to perform common surgical procedures.
[11] Bureau of Labor Statistic. Consumer Price Index 2018.
[12] Estimates of disposable costs from Ho et al.; estimate of 250 robotic cases per year based on C Ho et al., Robot-Assisted Surgery Compared with Open Surgery and Laparoscopic Surgery: Clinical Effectiveness and Economic Analyses (Technology Report No. 137) (Ottawa: Canadian Agency for Drugs and Technologies in Health, 2011); Canadian to US exchange rate from Bank of Canada. Currency Converter 2019.
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