Letters

RESEARCH LETTER

Estimation of the Acquisition and Operating Costs for Robotic Surgery

Despite evidence questioning the clinical benefit,[1] the use of the robotic platform for surgical procedures is increasing.[2] No benchmark exists for the cost of acquiring and operating robotic systems, and previous cost evaluations have either omitted key expenses[1] or utilized billing records that do not itemize costs with sufficient granularity.[2] Because 1 company supplies most robotic technology, and all their revenue comes from system, service, and instrument sales, the minimum cost to hospitals can be estimated by examining the revenue in this company's financial statements. Establishing a cost benchmark can inform future cost-effectiveness evaluations.

Methods | The financial statements of Intuitive Surgical Inc (Form 10-K annual reports) from January 1999 to December 2017 were retrieved online.[3] The Form 10-K is an annual report required by the US Securities and Exchange Commission that provides a summary of a company's finances. Filings are independently audited and verified by the chief executive officer. Data were extracted and summarized for robot system sales, revenue sources (systems, service, instruments and accessories; rounded to the nearest $100 000) and approximate procedure volumes by specialty (gynecology, general surgery, urology). Procedure information is entered into the robotic platform for each case and is transmitted to the company. "Robot systems" refer to the sale or lease of the platform. "Service" refers to the maintenance and training contract. "Instruments and accessories" include finite-lifetime parts, endoscopes, simulators, and supplies (eg, drapes). To hospitals, system revenue is an acquisition cost with service and instrument and accessory revenue as fixed and variable operating expenses, respectively.

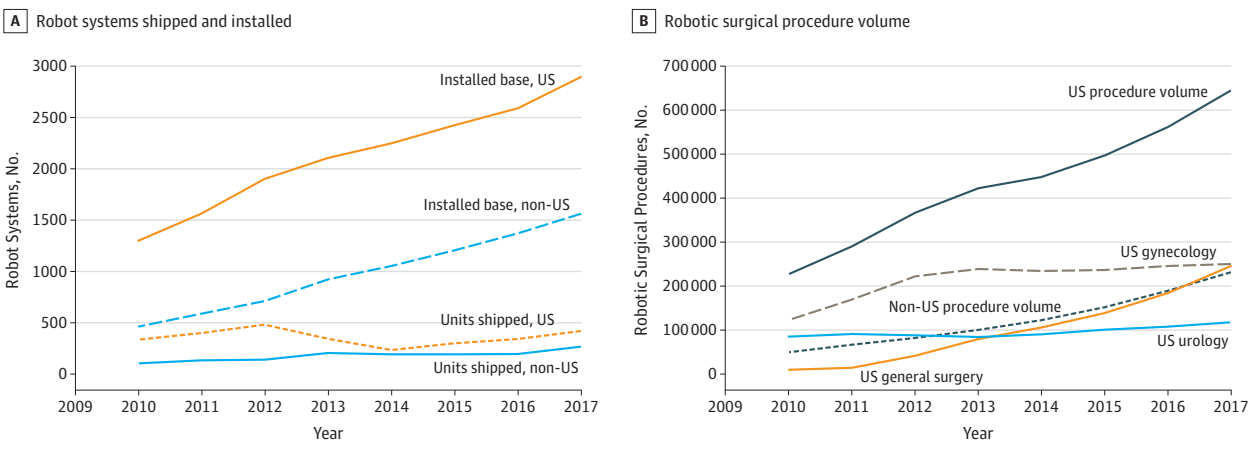
Results | By the end of 2017, the company shipped 5770 robot systems; after accounting for trade-ins and returns, 4409 platforms were installed globally including 2862 (65%) in the United States (**Figure**, A). The estimated annual procedure volume increased from 136 000 in 2008 to 877 000 in 2017. In 2017, 644 000 procedures (73%) were performed in the United States (**Table**). From 2010 to 2017, general surgery procedure volume increased the fastest (10 000 to 246 000) followed by gynecology (123 000 to 252 000) and urology (85 000 to 118 000) (Figure, B).

Total revenue in 2017 was $3.1 billion, with $2.3 billion (73%) domestically (Table). In 2017, 52% of revenue was derived from instruments and accessories, 29% from robot systems, and 19% from service. Dividing the total spending on robotic technology by the total number of robotic procedures performed in 2017 yielded a cost per procedure of $3568, with $1866 for instruments and accessories, $1038 for robot systems, and $663 for the service contract.

Discussion | The robotic surgical procedure market is large and increasing; in 2017, hospitals paid the primary supplier more than $3 billion, equating to $3568 per procedure.

Before robotic surgery, total operating room costs for common general surgery procedures ranged from $3000 (cholecystectomy) to $7000 (pancreatectomy).[4] Instruments account

Figure. Robot System Shipments and Installations and Procedure Volume Data, 2010-2017



Installed base indicates units shipped minus trade-ins and returns. Although the overall structure of each financial statement is similar, some individual data points were not reported for the entire study period. For example, US procedure volume was introduced in 2010. To avoid introducing unsubstantiated assumptions, data are only presented when continuous elements are available for all years until 2017.

Table. Robot System Sales, Robotic Procedure Volume, and Revenue Data in 2017[a]

Characteristic	Value
Robot System Sales, No.[b]	
Units shipped	
Global	684
United States	417
Non-United States	267
Installed base	
Global	4409
United States	2862
Non-United States	1547
Robotic Procedure Volume, No.[c]	
Global	877 000
United States[d]	644 000
Gynecology	252 000
General surgery	246 000
Urology	118 000
Revenues, $	
United States	2 279 800 000
Total revenue	3 128 900 000
Robot systems	910 200 000
Instrument and accessory[e]	1 636 900 000
Service[f]	581 800 000

[a] Except for the installed base, all values represent data for the period from January 1, 2017, to December 31, 2017. The installed base is accurate as of December 31, 2017, and reflects the total number of units shipped minus trade-ins and returns since company inception.

[b] Systems refer to the sale or lease of the platform.

[c] Procedure data are estimated by the company and ascertained through the platform's operative logs.

[d] Gynecology, general surgery, and urology data do not add to overall US data because of other, low-volume surgical procedures that are not itemized in the financial statements (eg, ear, nose, and throat; thoracic).

[e] Instruments and accessories include finite-lifetime parts, endoscopes, simulators, and disposable supplies (eg, staplers, drapes).

[f] Service refers to the maintenance and training contract.

for less than 20% of this cost[5] because they are relatively inexpensive. For example, the marginal cost of a reusable instrument set is less than a few hundred dollars per procedure and disposable instruments, although more expensive, still cost less than $1000 for common laparoscopic procedures.[6]

In this study, the instruments and accessories used in robotic surgery cost an average of $1866 per procedure. In part, this reflects a limitation imposed by the company because of specifications to not use most instruments for more than 10 procedures. To our knowledge, no clinical data support this limit. In addition, $1701 per procedure was dedicated to purchasing and maintaining the system, costs that are novel to robotic surgical procedures.

The primary limitation of this study is the ability to estimate only the hospital costs imposed by the manufacturer. Because robotic surgery increases operating room time,[1,2] and there are other hospital expenses such as staff training, infrastructure upgrades, and marketing, this study's estimate represents the lower bound for the total cost of this technology. Reductions in downstream expenses, such as reduced length of stay, may offset these costs. However, especially in robotic vs laparoscopic comparisons, there are few data supporting this assertion.[1,2]

The continued use of the robotic platform in surgery requires demonstrating the superior clinical benefit of these devices while considering the full set of costs for these systems.

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COMMENT & RESPONSE

Sepsis as a Cause of Infectious Disease Mortality

To the Editor Dr el Bcheraoui and colleagues reported a decreasing trend over time and large geographical variability in mortality from infectious diseases in the United States