14 Achieving Financial Optimization of a da Vinci Robotic Program While Achieving Best Clinical Outcomes

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14.1 Introduction

Today, there is a steady and highly desirable migration from open to minimally invasive surgery (MIS) worldwide [1]. Yet, the number of annual global MIS cases, estimated at 20 million, represents only a small percentage of the total 100 million surgeries performed globally each year [2, 3].

Within the subset of MIS cases lies da Vinci-based robotics, with its comparatively small—but steadily increasing—robotic case volume, estimated at approximately one million surgeries annually, performed at an estimated 3000 US and 2000 European/Asian da Vinci robotic programs worldwide [4].

Even though growth in robotic surgery demands the attention of administrative and clinical leadership, robotic surgery still plays a relatively minor role in the overall surgical program compared to other surgical service lines. However, when the annual case volume of surgical service lines such as orthopedics, neuro/spine, cardiac, and trauma is added to the da Vinci case volume, the total number of robotic cases becomes considerably more significant. The overall global minimally invasive surgery market is forecast to be worth $36.5B USD in 2018, and it is forecast to grow to $58B USD in 5 years [5]. Robotic programs are thus expected to continue their steady growth over the coming decade and beyond. Real-world experience suggests that this expansion is rooted in factors ranging from improved clinical experience for patients and surgeons to fiscal factors, aggressive vendor marketing, surgeon preference, and hospital-to-hospital competition in order to attract patients and to recruit new and established robotic surgeons and personnel.

Moreover, hospital administrators and surgical leadership face an increasing number of robotic vendors and technologies, creating considerable pressure to launch new—or expand existing—robotic programs across an ever-growing array of surgical service lines and case types. Additional challenges faced by hospitals include the onus of rigorous documentation requirements for evaluating surgeon skills, outcomes, and ongoing performance. This collectively necessitates more comprehensive approaches to robotic program governance, expansion in supply/reposable management, improved approaches to surgeon and crew training, the need for ever more powerful data management and superior analytics, and more.

14.2 Creating a Robotic Program

One common oversight of many new and even existing robotic programs is the belief that having robotic surgeons and one or more robots means that the hospital has a robotic program.

A robotic program, to be sure, requires surgeons and technology, but that does not qualify as a program. To achieve desired programmatic outcomes, the seamless integration of robotic stakeholders—governed by a unified body of planning, objectives, policies, and procedures—is needed to achieve the goal (Fig. 14.1). Administration, surgeons, and technology, working together, must incorporate operational goals, strategic planning, tactics, clearly defined stakeholder roles and responsibilities, comprehensive approaches to surgeon and crew training, performance benchmarking, team communication, accountability, and continuous improvement processes. These initiatives must be aimed at driving the value of robotics and new robotic technologies. The bottom line is that improved quality together with lower costs contributes value to the healthcare system. All stakeholders must align on these goals, identify the available metrics and data necessary to corroborate improved performance, and work as a team to achieve these improvements and best practice standards.

In the absence of strong provider-administration alignment—or faced with poor surgeon performance metrics, or lack of governance policies, or weak data management and

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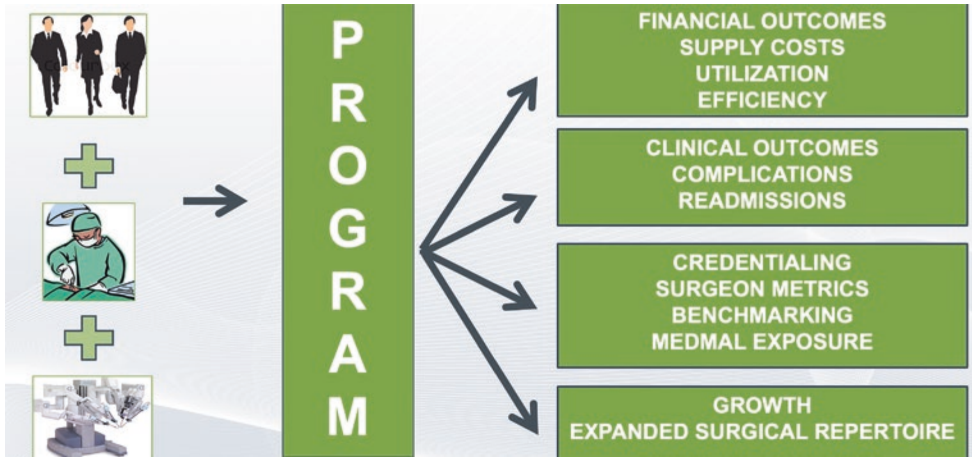

Fig. 14.1 Robotic stakeholder integration and interreliance

analytics—significant programmatic dysfunction likely results. Patients will suffer from increased risk and lower quality clinical outcomes, and the hospital will suffer from increased cost and lower margins. Given that robotics is a "team sport," the optimal contribution of all stakeholders across multiple categories of activities is essential.

14.3 From Program Launch to Best Practice: The Path to Maturity

In the early phase of a new robotic program, most hospitals depend on their robotic technology vendor(s) for basic training and "quick start" program support. Once the program advances to even modest annual case volumes, however, a wide range of critical management issues typically emerge, thus begging the question how does a hospital or integrated delivery network (IDN) optimize its massive, and usually ever-expanding, investment in robotic technologies? At this point, the vendor–client relationship typically becomes less helpful programmatically.

To be clear, the management of a robotic program to a level of best practice requires knowledge that goes considerably beyond what the robotic technology vendor provides, and beyond what most hospital administrators and clinicians acquire during their hard-fought robotic program on-the-job training experience. Vendor-sponsored "solutions" to program management often leave customers questioning their recommendations and materials, given the obvious commercial motives of industry to sell more technology and supplies to end users.

14.4 Appropriate Robotic Patient Selection

Not all MIS cases should be performed robotically for a variety of reasons; appropriate robotic patient selection is therefore very important. A more comprehensive surgical strategy should be implemented to derive maximum value from robotics for the hospital/IDN and its patients. The fact is, understanding comprehensive robotic performance metrics beyond merely the cost of capital equipment and ongoing robotic supply acquisition is outside the scope of the vendor relationship. This is why such things as surgeon credentialing, privileging, clinical outcomes data management, staffing decisions, nonrobotic supply utilization, payer issues, case scheduling, robot access strategies, and policies—and many other "local decisions"—should not be influenced by vendors who are motivated by sales and increasing case volumes.

Another important component of every robotic program is surgeon training. Hospitals with adequate clinical and financial data on historical open and laparoscopic cases are better positioned to make wise choices regarding how best to train their robotic surgeons. The long-range goal is always to achieve improved comparative value in robotics vs open and laparoscopic cases. Adequate case volume to support the learning curve is a key component of surgeon selection: low volume robotic surgeons may never progress through the learning curve itself [6].

14.5 Cases Complexity Designations

Another framework to help assure appropriate case selection lies in the use of classifying robotic case complexity. For example, some robotic programs classify cases as either low complexity (simple or basic cases) as opposed to complex (or advanced) cases. In general, surgeons should use simpler procedures for approximately the first 20 robotic cases until comfort with the robotic controls is second nature and attention can be focused on the steps of more complex cases rather than the robotic controls. Best practice programs also recognize that low margin cases are better for training than high margin cases. This is because, from a financial perspective, longer operating room (OR) times, typical during the learning curve, are more acceptable in cases with lower profitability. Said another way, longer case times may have an unacceptable, negative impact on higher margin cases, thus impacting the profitability of surgery as a whole in the hospital. Often, it becomes clear that some surgeons and some cases are not appropriate robotic cases; in these situations, surgery should continue to be done laparoscopically [7].

At the end of the day, achieving strong fiscal and clinical return on investment remains a key—yet often illusive—objective for many administrative and clinical leaders, commonly faced with running their robotic program through trial and error, peer-to-peer exchange with colleagues, findings provided in peer review literature, and limited vendor-based intel—for better and for worse.

14.6 Stumbling Blocks: Defining the Problems

Robotic surgery entered the market in the era of big data development [8]. Heading into the 2020s, electronic medical records (EMR), cost accounting, and supply data are captured to a degree unknown 30 years ago during the launch of laparoscopy. This significantly more-focused orientation toward data, which coincided with the advent of value-based healthcare, helped drive the desire to assess to what degree robotic surgery was equivalent to, if not better than, open and laparoscopic surgery both financially and clinically [9].

The initial comparison of robotic surgery to laparoscopy was also driven by the regulatory approval process followed by the FDA and Intuitive Surgical. The benchmark for safety and equivalency was laparoscopy. Robotics was not treated like a new technology, but rather as a comparative technology to laparoscopy. As a result, clinical efficacy data were lacking at launch; it would be at least a decade before case-specific efficacy data were published in the literature.

This focus on comparing robotics to laparoscopy served to introduce several confounding variables into the early clinical and financial results. No new procedure codes were introduced, meaning that robotic case reimbursement was and remains nearly equivalent to laparoscopy despite some early hospital billing practices that attempted to upcharge for robotic surgery. Clinical outcomes and costs associated with robotic surgery were also reported in the literature early on as uptake of robotics was developing and at a time when surgeon learning curves had a powerful impact on operative times, supply utilization, clinical outcomes, and costs. Yet during the first decade of robotic surgery adoption, the learning curve was almost ignored in the comparative studies. As a result, the fiscal and clinical findings pertaining to robotic surgery in the early 2000s were not compelling, but also not dissimilar to that of laparoscopy in the late 1980s.

By 2008, the quality and efficiency of robotic surgery was viewed as inferior to laparoscopic surgery (i.e., longer robotic case times and increased cost with similar outcomes to laparoscopy at best). As scores of early papers studying robotics emerged in the peer review literature during this era, clinical and financial outcomes largely centered around urologic- and gynecologic- specific robotic surgery that reinforced the perception of robotics costing too much and taking too long vs. laparoscopy. Soon, this perception became reality for many surgeons and administrators as they too generated similar results at their institutions due to lack of understanding that robotic surgery is not a modification of laparoscopy, but rather is a paradigm shift in the way surgery is performed. With the notable exception of prostate surgery, this viewpoint is still common today.

However, during this phase of robotic development, some insightful surgeons also began to observe an emerging trend. As a surgeon's annual robotic case volume increased, the efficiency of his or her cases increased (i.e., shorter case times) together with reduction in costs (associated with less consumption of da Vinci and non–da Vinci supplies). In the hands of increasingly experienced robotic surgeons, with an eye to appropriate case selection, certain performance metrics (i.e., reduced length of stay (LOS) and readmissions vs. laparoscopy) for certain robotic case types began to equal or even overtake equivalent laparoscopic cases, notably in hysterectomy and other benign Gyn case types. Robotic patient satisfaction scores were also higher in many areas, centered around reduced pain and qualitative factors like perceived faster return to work [10]. Additional clinical evidence developed supporting improvements in blood loss, transfusion risk, infection rates, wound complications, readmissions, reoperations, and case-specific outcomes improvements. Studies were also published that attempted to quantify the robotic surgery learning curve as well as case volumes necessary to attain proficiency [11].

As time went on, some leading robotic surgeons began to advance the notion that, to achieve more cost-effective robotic surgery, it was very important for surgeons to understand that robotic surgery should be thought of as more closely aligned with open surgery in its use of supplies rather than being a duplicative surgical approach mirroring laparoscopy, except with an extra layer of expensive robotic technology added on top of it. Expensive single-use disposable devices to mitigate the shortcomings of laparoscopy were no longer needed for robotic surgery. Improved suturing capability and reposable energy devices could replace these single-use devices. This key insight helped to shift the cost equation in robotics toward not only equality with lap in a large number of Gyn and general surgery cases, but even superiority in some procedures [12].

While robotic programs struggled to untangle the guiding principles, policies, and procedures necessary to codify and scale these early insights into a systematic approach to running a robotic program, the burgeoning demand for robotic technologies pushed program management into the background. There was no robotic program play book to rely upon as patient demand, market demand, aggressive vendor marketing, and surgeon preference ruled the day. Adding more complexity to this dynamic were the challenges faced when IDNs sought to integrate disparate robotic programs from among multiple hospitals within a single system (each facility often with a different program scope and performance level, sometimes using differing EMR or accounting software) into a unified program and governance body. The net result was a blank check mentality on the part of hospital administration who felt compelled to support robotic programs and robotic surgery despite a lack of coherence regarding program governance, and in many cases, demonstrated clinical or fiscal value.

14.7 Data as the Critical Denominator

Looking for a common denominator to address this operational challenge, data were, and remain, the key. Data must be recorded on case times, costs (both da Vinci- and non–da Vinci-related), clinical performance, and select quality parameters (such as estimated blood loss, length of stay, and complications), though those endpoints remain infrequently captured. For most institutions, the question was whether the needed data were available. If it was, was it accurate? How should it be analyzed? What fiscal and operational performance benchmarks could be used? How could a surgeon, let alone a nonclinical administrator, make sense of such comparative data on cost, or case time, or clinical quality? In the early going of robotic surgery, there were few reliable answers to these questions.

Fifteen years later, although many more answers are available, many institutions continue to struggle through these issues [13]. Although they operate in a robust data environment, it is one typically maladapted to the strategic needs of institutional leadership, that is, the desired data exist to some extent, but without a structured approach to integration, normalization, and analysis.

14.8 Data Management Must Include Powerful Analytics

Data accuracy is critical for a robotic program to achieve optimal financial and clinical performance. However, facilities must also include the analytics that derive from the normalized, audited data. Whether this capability is achieved through a custom-designed software application or through a consultant/third-party vendor, robotic program leadership must have access to essential data analytics in order to achieve lower costs, financial performance improvement, and superior program efficiency/clinical quality. The goal is reliable, fully transparent performance reporting, aligned with best practice robotic benchmarks, to drive improvement in cost, profitability, case time, throughput efficiencies, supply and reposable utilization, case selection, comparison of surgeon performance metrics, complications, readmissions, reoperations, patient satisfaction, and many other quality and operational metrics (Fig. 14.2).

One example of an analytic platform that facilitates robotic program optimization is summarized, in part, below. Called CAVAlytics™ (CAVA Robotics International, LLC), this software application and real-world surgical performance database ingests and translates hospital EMR, cost accounting, and supply data into actionable information for hospital leadership. The software sits on a large surgical database of open, laparoscopic, and robotic cases that enables the data of a given hospital/IDN to be sorted, filtered, and compared in a meaningful way to assess per-

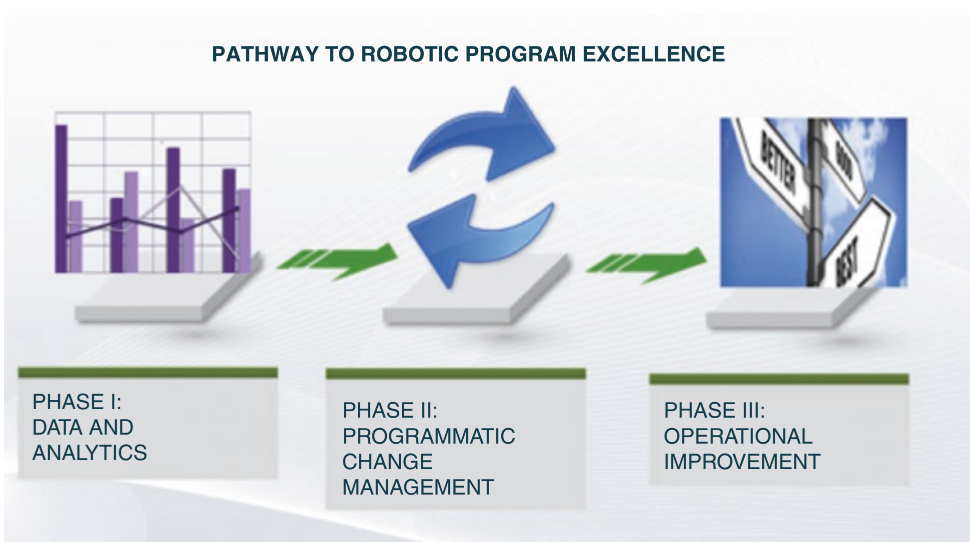

Fig. 14.2 Program excellence

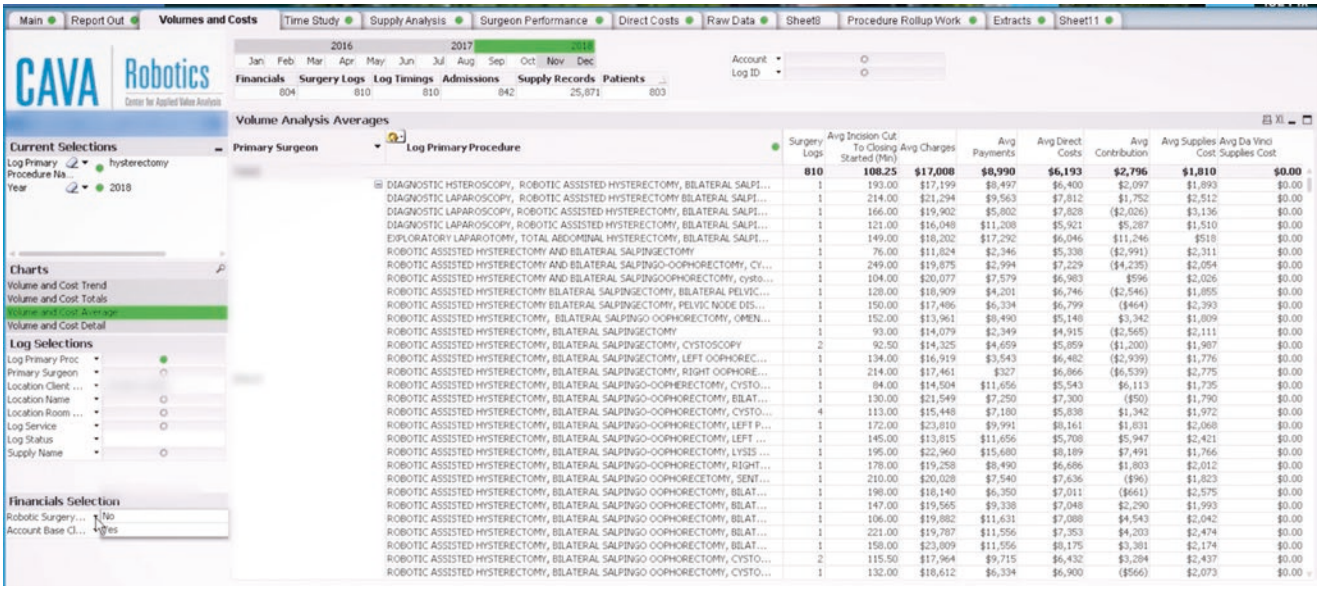

Fig. 14.3 Example of a Robotic Program Data Analytic Platform. © 2019 CAVA Robotics International, LLC. (Reprinted with permission)

formance and to drive change. Ingested data include audited clinical, cost, and supply records. The platform filters data for date ranges, individual surgical procedures, and any specific robotic surgery case type or surgeon in the database. Time study metrics are included examining robotic team performance such as patient in room to incision time, incision close to patient out of room to recovery in the post-anesthesia care unit (PACU), and many others. All time stamps captured by the EMR or other facility software can be analyzed or filtered by location, case type, surgeon, or any other custom-designed metrics. These filters carry forward throughout the analyses of supplies to enable screening for high-cost items, comparing individual surgeons' supply variation and average usage on any given month or day. Monthly reports are provided for committee meetings, providing transparent illustration of comparative surgeon-by-surgeon benchmarking, including cost, supplies, case time, and select quality metrics (Fig. 14.3).

14.9 Program Optimization: Other Key Factors

Once the full complement of data management and analytics are in place, a central and significant component of the program's infrastructure has been realized. But excellent data management and analytics by itself does not produce robotic program optimization. Other key factors include the following:

- *Engaged clinical personnel*
- *Clearly defined vision/objectives for the program*
- *Strong clinical and administrative leadership with excellent alignment*
- *Program infrastructure: committee/governance structure and policies*
- *A well-trained, experienced robotic coordinator*
- *A surgeon training program and policies, including simulation*
- *Clear surgeon credentialing and privileging pathways*
- *An OR crew training program*
- *Credentialing and privileging policies and procedures*
- *A high-quality business plan and pro forma focusing on healthy growth*
- *Stakeholder accountability*
- *A robotic culture of performance transparency*
- *A clearly defined technology footprint and contracting*
- *Superior scheduling policies and procedures*
- *Technology management and troubleshooting*
- *A vendor management policy*

As noted earlier, robotics is truly a team sport when performed at the highest level. Taken as a whole, the key dimensions of functionality in the list above integrate into a well-run robotic steering committee, driven by an experienced robotic coordinator and supported by an engaged robotic chair, a surgeon steering committee, and administration, all of whom cross reference each other in a path to best practice performance optimization.

14.10 The Stages of Program Maturity

Moreover, there is a continuum of maturity that a robotic program moves through, encompassing close to two dozen distinct categories or dimensions of activity. Each one of these dimensions effectively stages the status of the robotic program, charting not only its progress but illuminating what work remains going forward to achieve the desired best practice performance objectives.

Examining the stages of maturity for each element of program performance, there are four distinct stages: Ad Hoc, Reactive, Good, and Best Practice (Table 14.1).

Most robotic programs begin, as noted earlier, in a state of weak overall management. Many of the key dimensions of program optimization are unknown or approached in a makeshift manner. This stage of program management is categorized as "Ad Hoc."

As a program advances, it becomes clearer that there are indeed many different elements at play in the operation of the robotic enterprise, yet a largely passive approach continues, with stakeholders typically reacting to issues on an ongoing basis. Appropriately, this stage of management is categorized as "Reactive." Both the Ad Hoc and Reactive stages of robotic program management leave a program experiencing highly significant programmatic variability in terms of supply and reposable use, surgeon performance/training, operational efficiency, and patient satisfaction, and almost always results in higher

Table 14.1 Robotic program maturity

ROBOTIC PROGRAM MATURITY

CAVA Robotics Program Category	Ad hoc	Reactive	Good	Best Practice
1. Program Vision and Strategy	■			
2. Administrative Leadership			■	
3. Surgeon Selection, Credentialing, and Privileging	■			
4. Surgeon Training, Mentoring, and Learning Curve	■			
5. Surgeon Quality Metrics		■		
6. Crew and RN Training and Performance Standards		■		
7. Program Governance, Policies, and Procedures	■			
8. Clinical and Med Exec Leadership Integration	■			
9. Data Collection, Integrity, and IT Management	■			
10. Data Analytics and Reporting			■	
11. Stakeholder Accountability	■			
12. Reposible and Supply Management	■			
13. Optimizing Patient Outcomes		■		
14. CAVA Best Practice Program Design	■			
15. Cost-Effectiveness	■			
16. Financial Performance and Cost Accounting	■			
17. Vendor Management, Data Sources, and Tools	■			
18. Technology Footprint and Agnostic Planning		■		
19. Centralized Communications	■			
20. Med Mal / Risk Management		■		
21. MIS and Robotics: Planning for the Future	■			

costs and weak overall financial performance together with suboptimal quality.

The next stage in robotic program maturity is categorized as "Good." A simple term, but with important performance implications, the Good stage reflects a robotic enterprise that has a proactive, strategic, and planful approach to each clearly defined area of its program. It has crafted a defined vision. Administrative leadership is engaged and aligned with the mission and performance targets of its surgeons. Surgeon credentialing, training, and policies are drafted and integrated into Med Exec functions and oversight. The program operates on the basis of sound data management and analytics. Governance of the robotic committee and the performance of all stakeholders are coordinated in an environment of accountability and transparency. The program is profitable and patients are consistently pleased with their robotic surgical experience.

Next, the most advanced stage on the robotic program maturity map is "Best Practice," achieved when a Good program achieves top tenth percentile performance or better in each quantifiable clinical and financial category, and it is concurrently in alignment with best practice policies and procedures in all other operational and qualitative categories.

14.11 Management of the Surgeon Learning Curve

Every robotic program faces the challenge of providing training and clinical support to its surgeons regarding ongoing performance quality. This challenge is most pronounced during the learning curve for all new robotic surgeons. During this phase, the robotic surgeon's focus is on skill acquisition and gaining clinical and technical experience, with case efficiency and cost-consciousness set aside. The objective for all stakeholders is to move the surgeon through the learning curve phase as safely, quickly, and correctly as possible. The faster and better this occurs, the shorter the period of risk to the patient as well as to the bottom line of the robotic program.

Management of the surgeon learning curve presents a steep incline for the vast majority of robotic programs, and quite often, it results in a scenario where, unbeknownst to administration, a large percentage of a hospital's robotic surgeons remain in the learning curve for an unacceptably long, costly period of time. Some surgeons, in fact, never progress through it, despite the fact that they may be into their 50th robotic case or beyond. Ongoing monitoring of case volume, operative times, cost, and a few basic clinical metrics can help identify surgeons who are lagging in development.

Figure 14.4 illustrates an actual IDN's scattergram of weighted composite quality metrics (case time and case costs) associated with a distribution of its robotic surgeon. Here, more than 50% of the surgeons failed to meet the minimum overall quality performance level target, defined by the dotted red trend line. If a robotic surgeon is represented below the learning curve, that surgeon exposes the patient and the hospital to increased clinical risks and costs the hospital more due to increased supply and reposable consumption together with the costs associated with increased OR time. Moreover, and sometimes far more significantly, the total cost of care goes up, due to increases in reoperations

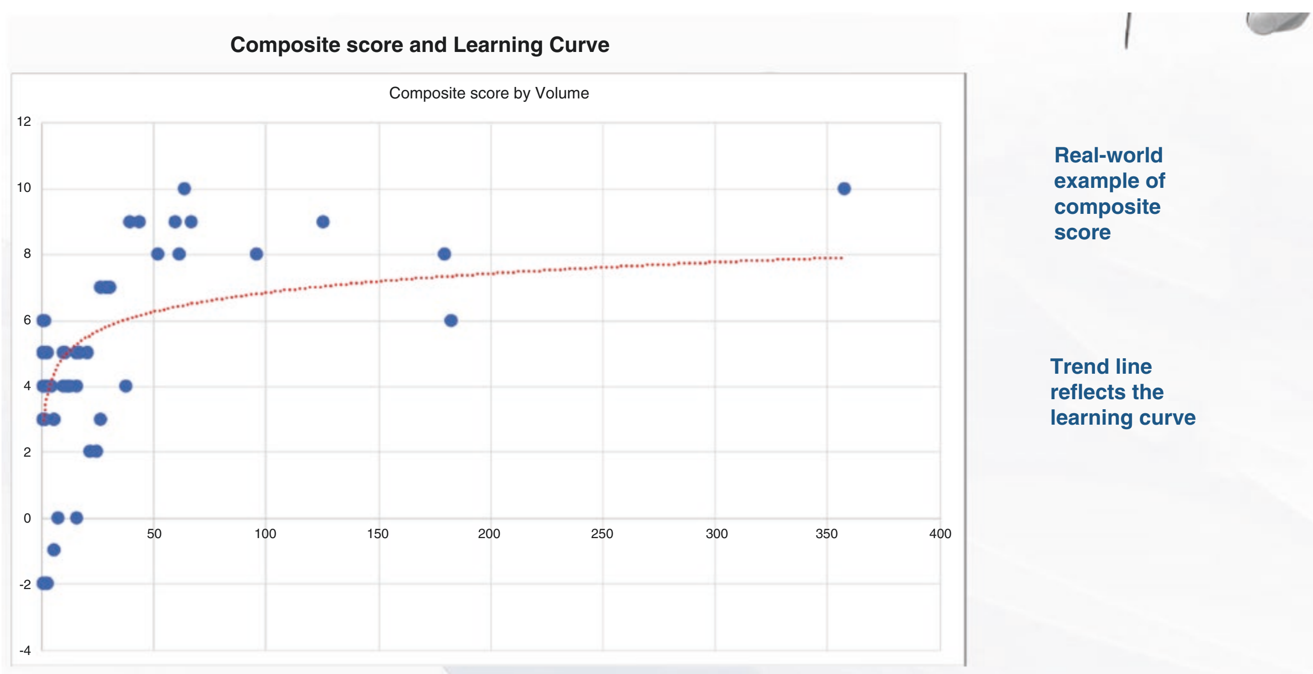

Fig. 14.4 Composite surgeon quality scoring

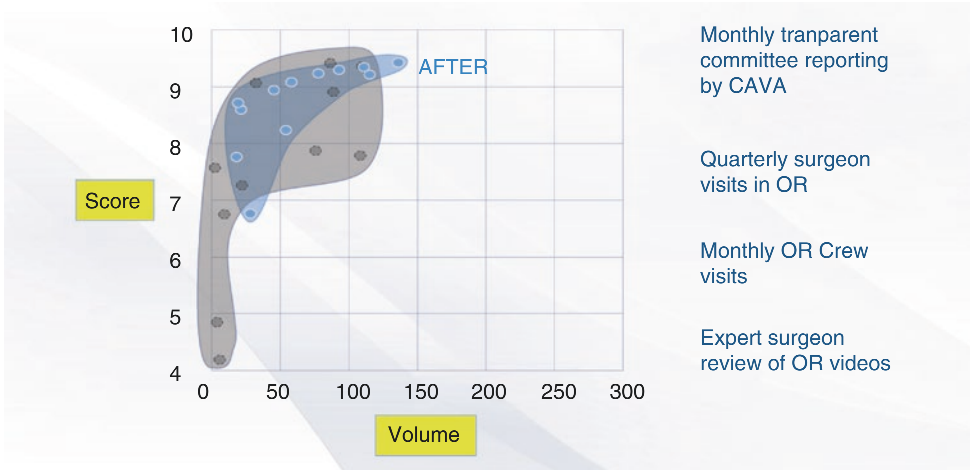

Fig. 14.5 Transition of surgeon quality scoring pre–post intervention

and readmissions. The robotic surgeon learning curve also has an impact on patients in terms of realizing (or failing to realize) all the potential clinical benefits that MIS offers. The bottom line is that the value of robotics goes down when costs go up and quality goes down.

What steps can be taken to address this weakness in the path to program optimization? Often, it is very difficult for a program to extract and assess the kind of insight they need to assess learning curve issues. They may have limited data access, or they may have a wide variation in software and systems within their IDN making head-to-head surgeon performance comparisons difficult to track in a meaningful way. Creating a weighted scoring system can help manage this issue under these circumstances.

For example, what is plotted in Fig. 14.5 is a distribution of weighted surgeon quality performance scores before a quality improvement intervention; the same surgeons are then plotted post quality improvement. Interventions included video case capture reviewed by senior mentor robotic surgeons; specific live OR training with surgeons and crew when needed; and a curriculum of simulation and training. Transparent reporting of all clinical and financial performance data often results in surgeon improvement because peer-to-peer monitoring and reporting drives competitive surgeons to strive toward personal improvement. The scattergram pre-intervention has a red trend line that mimics the majority of other robotic learning curves seen in the published literature [14–16].

Below, the red trend line is surgeon performance/quality metrics that need to improve to above the red tend line, even if it means dropping case volume for a short period of time. The goal was for the hospital to have as many of its surgeons tightly parked in the upper left corner, above the red trend line, postintervention, which it accomplished.

14.12 Standardized Cost Accounting Methods

Another key to driving a robotic program to financial and clinical optimization and best practice performance is being certain that robotic cost accounting methodologies are consistent and applied in an equivalent manner to those of laparoscopic technology. Capital and service costs are often included for the robot and are distributed across the case volume equally, whereas capital costs associated with laparoscopy are usually never applied in this way to the laparoscopic cases. Complicating such an assessment is the lack of standardized cost accounting methodologies among hospitals. Robotic capital costs are frequently amortized across all robotic cases. Yet when capital costing data are pulled for traditional laparoscopy, orthopedics, and other procedure-based service lines, facilities frequently follow different cost accounting methodologies. Comparing the actual direct and total costs of a da Vinci robot vs. other surgical technologies is therefore challenging. For example, some hospitals place robotic surgery in the highest cost tier and add a per-minute surcharge to the case for specific portions of the case to cover the high instrument cost. Some capitalize the cost of the instruments. Some track the use of each instrument in order to capture the actual cost per use. Only when compared correctly to lap and other service lines is it possible to achieve an equitable comparative cost assessment with robotics.

14.13 Summary: The Key Steps to Robotic Program Optimization

Achieving financial optimization of a da Vinci robotic program while achieving best clinical outcomes is a team process requiring multiple concurrent, proactive, data-driven steps by clinical and administrative stakeholders working together closely, guided by a clear programmatic vision, policies, procedures, accountability, and performance transparency. The vision and goals should always focus on improved value directly related to improved clinical quality at a lower cost. Alignment with the guidelines outlined in this chapter helps a program advance from the earlier stages of a program's life cycle to that of a mature, well-structured, strategically sound enterprise that enjoys profitability, efficiency, and, above all, high-quality healthcare delivery to patients seeking the significant benefits of minimally invasive surgery in general and robotic surgery in particular.

References

1. Tsui C, Klein R, Garabrant M. Minimally invasive surgery: national trends in adoption and future directions for hospital strategy. Surg Endosc. 2013;27:2253.
2. Weiser TG, Regenbogen SE, Thompson KD, et al. An estimation of the global volume of surgery: modelling strategy based on available data. Lancet. 2008;372(9633):139–44.
3. Weiser TG, Haynes A, Molina G, et al. Size and distribution of the global volume of surgery in 2012. Bull World Health Organ. 2016;94(3):201–209F.
4. Intuitive Surgical Annual Report. 2018. p 45.
5. Minimally invasive surgery market: global industry trends, share, size, growth, opportunity and forecast 2019–2024. Research and Markets.
6. Woelk JL, Casiano ER, Weaver AL, et al. The learning curve in hysterectomy. Obstet Gynecol. 2013;121(1):87–95.
7. Heemskerk J, van Gemert WG, de Vries J, et al. Learning curves of robot-assisted laparoscopic surgery compared with conventional laparoscopic surgery: an experimental study evaluating skill acquisition of robot-assisted laparoscopic tasks compared with conventional laparoscopic tasks in inexperienced users. Surg Laparosc Endosc Percutan Tech. 2007;17(3):171–4.
8. Islam MS, Hasan MM, Wang X, et al. A systematic review on healthcare analytics: application and theoretical perspective of data mining. Healthcare (Basel). 2018;6(2):54.
9. Feldstein J, Schwander B, Roberts M, Coussons H. Cost of ownership assessment for a da Vinci robot based on US real-world data. Int J Med Robot. 2019;15(5):e2023. https://doi.org/10.1002/rcs.2023.
10. Giri S, Sarkar DK. Current status of robotic surgery. Indian J Surg. 2012;74(3):242–7.
11. Schreuder HWR, Wolswijk R, Zweemer RP. Training and learning robotic surgery, time for a more structured approach: a systematic review. BJOG. 2012;119:137–49.
12. Feldstein J, Coussons H. Achieving robotic program best practice performance and cost versus laparoscopy: Two case studies define a framework for optimization. Int J Med Robot. 2020;1–8. https://doi.org/10.1002/rcs.2098.
13. Mehr S, Zimmerman M. Robotic-assisted surgery: a question of value. Am J Manag Care. 2014.
14. Hopper AN, Jamison MH, Lewis WG. Learning curves in surgical practice. Postgrad Med J. 2007;83(986):777–9.
15. Maruthappu M, Duclos A, Lipsitz SR, et al. Surgical learning curves and operative efficiency: a cross-specialty observational study. BMJ Open. 2015;5:3.
16. Mazzon G, Sridhar A, Busuttil G, et al. Learning curves for robotic surgery: a review of the recent literature. Curr Urol Rep. 2017;18:89.