Review of Management and Economic Engineering
Vol. 23, Nr. 1(91), March 2024, p. 49 - 56, ISSN (print): 1583-624X, ISSN (online): 2360-2155

OPERATING-ROOM TIME MANAGEMENT DURING ROBOTIC-ASSISTED SURGERIES - CASE STUDY

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Abstract: The main purpose of this research is to analyse Operating Room (OR) time management during Robotic-Assisted Surgeries (RAS) for two common urologic procedures - Robotic Assisted Radical Prostatectomy (RARP) and Robotic Assisted Partial-Nephrectomy (RAPN). Over the last 6 months we recorded data from 60 RARP and 10 RAPN which were performed by one surgeon with a lot of expertise in RAS and laparoscopy. We divide the time data in fixed OR time: in-room to anaesthesia-release time (IRAT), anaesthesia release time to timeout (ARTO), timeout to cut time (TOCT), close to wheels-out time (CTWO) and variable OR time which is procedural time, from cut to close (CTCT). Analysing the OR time management, we concluded that a median fixed OR time for RARP covers 24,09% and 27.36% for RAPN. Any influence between the time of day and time-management during surgeries was not observed. A median time for RARP is 274 minutes and for RAPN is 265 minutes. OR times in RAS are important to be managed correctly and efficiently, for maximising the benefits of minimal-invasive surgical care. (non-procedural)

Keywords: radical prostatectomy, partial nephrectomy, operating-room time management, robotic-assisted surgery

1 INTRODUCTION

Robotic-assisted surgery (RAS) represents a pivotal innovation in the context of minimally invasive surgery (MIS), setting a new benchmark for precision, flexibility, and control in surgical procedures. This advanced approach integrates cutting-edge robotic technology with the expertise of surgeons, facilitating complex operations through smaller incisions. The advent of RAS brings a lot of benefits over traditional surgical methods, including reduced recovery times, diminished pain, and lowered complication rates. Da Vinci Surgical System, developed by Intuitive Surgical, is considered the most advanced robotic-assisted surgical technology.

Operating Room (OR) time management is a critical aspect of healthcare delivery, affecting not only the efficiency and productivity of surgical services but also patient outcomes. According to a recent study, fixed operating room time points accounted for up to 49% of the overall operation time in robotically assisted urologic surgery (Geldmaker, L. E., Hasse, C. H., Baird, B. A., Haehn, D. A., Anyane-Yeboah, A. N., Wieczorek, M. A., ... & Thiel, D. D., 2022).

Moments such as the patient's delivery to the operating room, intubation, placement of anaesthesia lines, surgical patient positioning, sterilisation of the operating field, reversal of the patient's anaesthesia, and stabilisation of the patient prior to their departure from the OR, this are considered fixed time points and should vary as little as possible between procedures. Surgeon operating times are variable time points that will vary more because of surgeon and patient circumstances.

2 EVOLUTION OF ROBOTIC-ASSISTED SURGERY

The genesis of robotic-assisted surgical systems traces back to the mid-1980s, initially aimed at ehancing surgical precision and overcoming the inherent limitations of human dexterity in laparoscopic surgery (Satava, R. M. (2002). Early iterations of surgical robots were rudimentary, designed to augment the surgeon's ability to perform fine, controlled movements. The evolution from these initial models to the sophisticated platforms of today has been driven by advancements in robotics, computer technologies, and digital imaging, culminating in systems that offer a huge precision, control and autonomy for the surgeon.

The most advanced technology in RAS today is da Vinci Surgical System, developed by Intuitive Surgical (see Figure 1). In the last few years, the market has gained other robots for surgical use and most of them replicate what da Vinci is offering: a console for the surgeon to have full autonomy, a patient-side cart with robotic arms, a 3D vision system with high quality for the image, and EndoWrist instruments that follow the surgeon's movements with enhanced precision (Yazicioglu, O., & Borat, O., 2021).

Figure 1. da Vinci surgical system. Source: Intuitive Surgical

Surgeons may examine the surgery site in high definition and three dimensions using robotic devices such as da Vinci surgery System. These systems also have instruments that can replicate the actions of the human hand with even more dexterity. This precision is particularly beneficial in complex procedures that require fine manipulation of tissues and organs. Also, RAS enable surgeries to be performed through small incisions, like traditional laparoscopic techniques but with greater accuracy. Smaller incisions result in less damage to the surrounding tissues and a reduced risk of infection, which can lead to several postoperative benefits for the patient. The minimally invasive approach has the main advantage of less hospital stay, faster overall recovery time, less postoperative pain and quicker return to a normal social life. Besides the patients benefits, RAS offers improved ergonomics for surgeons, reducing the physical strain and improving surgeons' ability to perform complex procedures.

As any technology, robotic systems also bring some challenges into the discussion. The initial acquisition and ongoing maintenance costs of robotic systems are significant. The high cost can be a barrier for many institutions, limiting access to robotic surgery for some patients. While robotic systems are designed to enhance surgical performance, mastering their use requires significant training and experience. Despite the advanced technology of robotic systems, one challenge is the limited tactile feedback (haptic feedback) available to the surgeon. The absence of the ability to feel tissues can require adjustments in surgical technique and relies heavily on visual cues. Integrating RAS into hospital workflows involves logistical considerations, including operating room setup time, maintenance of equipment, and training of support staff. These factors can impact the efficiency of surgical services and require careful planning and management. With new platforms and technologies developing to extend the possibilities of robotic procedures, the field of robotic assisted surgery (RAS) is always growing.

Single-port systems, for example, offer even less invasive actions via a single point of entry, leading to better cosmetic results and shorter recovery period. Furthermore, the addition of artificial intelligence (AI) and machine learning (ML) to RAS would improve surgical planning, intraoperative guidance, and postoperative care, marking a significant leap forward in surgical precision and patient outcomes (Yang, G. Z., Cambias, J., Cleary, K., Daimler, E., Drake, J., Dupont, P. E., ... & Taylor, R. H., 2017).

3 IMPORTANCE OF OPERATING ROOM TIME MANAGEMENT

Implementing best practices in OR time management is essential for delivering high-quality, efficient, and patient-centred surgical care. Effective time management in the OR can lead to significant benefits, highlighting its importance for several key reasons. First, it improves patient outcomes because an efficient use of OR time can reduce the duration a patient spends under anaesthesia, potentially decreasing the risk of complications such as infections and facilitating quicker recovery times. Second, it improves resource utilisation - effective time management in the OR ensures that surgical teams, equipment, and facilities are used optimally.

Operating rooms are among the most resource-intensive units within a hospital. Efficient scheduling and reduced turnover times between surgeries can significantly decrease operational costs, including staffing, utilities, and the use of medical supplies. Also, good OR time management enables a healthcare facility to maximise the use of its surgical suites, allowing for a higher volume of surgeries to be performed. Last, but not least, monitoring and managing OR time can provide valuable data for quality improvement initiatives. Analysing the factors that lead to delays or inefficiencies can help identify areas for process improvement, training needs, or the adoption of new technologies.

Robotic setup time, which Kozminski, D. J., Cerf, M. J., Feustel, P. J., & Kogan, B. A. measured in 2020 as the interval between the beginning of the surgery and the start of the console, was found to be the least for prostatectomies and the longest for their "other" category, which included pyeloplasty and cystectomy, while renal procedures fell in the centre.

Minimally invasive surgery has advanced significantly since the da Vinci robotic technology was introduced into surgical operations, providing improved control, flexibility, and precision. Nonetheless, the level of complexity involved in setting up and controlling such advanced equipment may significantly impact the productivity and schedules of operating rooms. Here are several ways in which the da Vinci robotic system impacts OR operations:

- In comparison to conventional laparoscopic surgical setups, the da Vinci robotic system requires a longer and time-consuming setup.

- The learning curve associated with gaining proficiency in robotic surgery can initially reduce OR efficiency, as procedures may take longer to complete.
- Integrating robotic surgery into existing OR workflows require adjustments to accommodate the physical footprint of the robotic system and the coordination of the surgical team around it.
- Unplanned downtime due to technical issues or routine maintenance requires careful scheduling.

4 METHOD

4.1 *Study cohort*

Over a 6-month period, we collected intraoperative data on 70 consecutive RAS (60 RARP and 10 RAPN) performed at a private Romanian hospital. Throughout the entire process, the da Vinci Xi surgical system was used (Intuitive Surgical Company Sunnyvale, CA, USA). The urologist surgical team had a considerable level of expertise and performed all the procedures, while the nurses and OR staff had different knowledge regarding the robotic system.

4.2 *Metrics analysis*

The purpose of the case study is to analyse time data related to key milestones during robotic-assisted surgeries.

Figure 2. OR times - fixed and variable

IRCT = In room time to cut time; CTCT = Cut time to close time; CTWO = Close time to wheels out time; blue - fixed times, yellow - variable times

We can divide the total OR time into fixed or nonprocedural operating time and variable or procedural operating time (see Figure 2). In-room time to cut time (IRCT) sums up all the steps for preparing the patient from the moment he enters in the OR until the first incision is made by the surgeon. Anaesthesia release time, the preparation of the robotic instrumentation, the robotic system itself, the disinfection of the surgical field and revision of the patient's details, all of them are part of the IRCT. This is followed by a variable operating time, the Cut time to close time (CTCT) which is influenced by surgeon's level of expertise and familiarity with the robotic surgical system, surgeon's skill level in performing specific procedures robotically, efficiency in instrument manipulation and tissue dissection. The last step is a fixed operating time, Close time to wheels out (CTWO) and is made up of awakening the patient and stabilising him before moving to post-anaesthesia care unit.

Figure 3 shows the most important time-steps of a surgery, from beginning to end. In room time is the exact moment when the patient arrives in the OR. Anaesthesia release time marks the end of the anaesthesia procedures, preparing the patient for the surgery. Next, is the time-out step, when the entire OR team is going through the patient's file. The time-out is also a time designated for team members to voice any concerns about the patient's safety or the procedure. The beginning of the surgery starts with the first incision, referred as cut time and the ending is known as close time. The last key point is the wheels out time marking the moment when the patient leaves the OR.

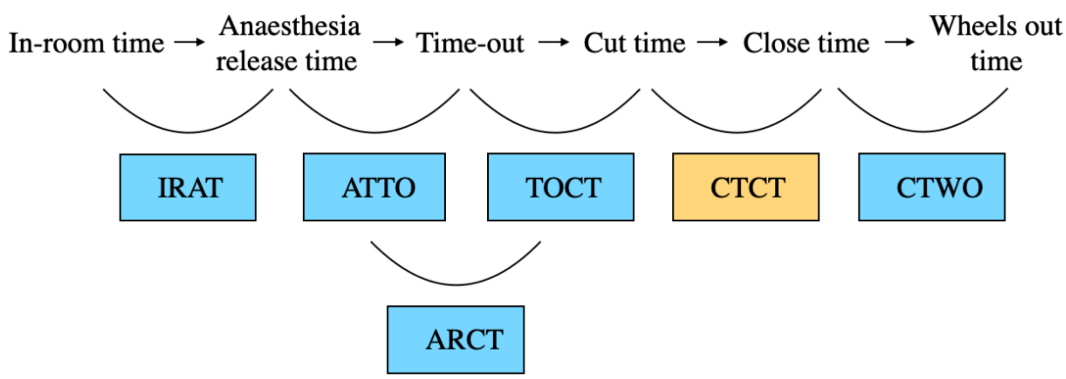

Figure 3. OR times - key milestones
IRAT = In room time to anaesthesia release time;
ATTO= Anaesthesia release time to timeout; TOCT = Timeout to cut time;
CTCT = Cut time to close time; CTWO = Close time to wheels out time;
IRCT = IRAT + ARCT; ARCT = ATT + TOCT= In-room time to cut time;
blue - fixed times, yellow - variable times

We can calculate the time gap between each step by distributing the milestones among different time periods. The steps involved in IRAT include transferring the patient to the operating table, administering a meticulous intubation, and setting up the anaesthesia lines. ARTO together with TOCT mark the Anaesthesia Release time to Cut time (ARCT) and consists of correctly positioning the patient on the operating table, regarding the anatomy that is going to be target, discussing the possible problems that may occur and preparing the surgical field by disinfection. Surgeon operating time is the interval between the Cut time and Close time, and this might vary depending on the operation done, case difficulty, patient considerations, surgeon expertise, and competence of OR staff.

4.3 Results

During a 6-month period, 70 robot-assisted surgeries were analysed - 60 RARP and 10 RAPN. For RARP, a median total procedure time was 274 minutes, the fastest one has a time frame of 180 minutes and the longest one took 372 minutes. For RAPN a median total procedure time was 265 minutes, the fastest one has a time frame of 206 minutes and the longest one took 395 minutes. Table 1 shows median values for OR times, both fixed and variable values, for each of the two robot-assisted procedures (RARP and RAPN) and median values for percentage.

Table 1. OR times for Urologic Robotic-Assisted Surgeries

OR time	RARP		RAPN	
	Mins	%	Mins	%
IRAT	20	7.12	22	9.82
ATTO	25	9.31	35	11.3
TOCT	4	1.45	3	1.03
CTCT	206	75.9	189	72.64
CTWO	10	4.21	8	3.64

Median IRAT time was longest for RAPN (22 minutes) and shortest for RARP (20 minutes). Median ATTO was longest for RAPN (35 minutes), shortest for RARP (25 minutes). TOCT median time was longest for RARP (4 minutes) and shortest for RAPN (3 minutes). CTCT median time was longest for RARP (206 minutes) and shortest for RAPN (189 minutes). CTWO median time was longest for RAPN (10 minutes) and shortest for RAPN (9 minutes). Looking at the OR time for RARP Analysis chart, we notice that the CTCT time occupy the largest part of the graph. The same situation can be seen in the RAPN analysis (see Figure 4). In both cases we have some outliers, which we can consider to be surgeries with extra time needed, due to possible clinical or technical complications.

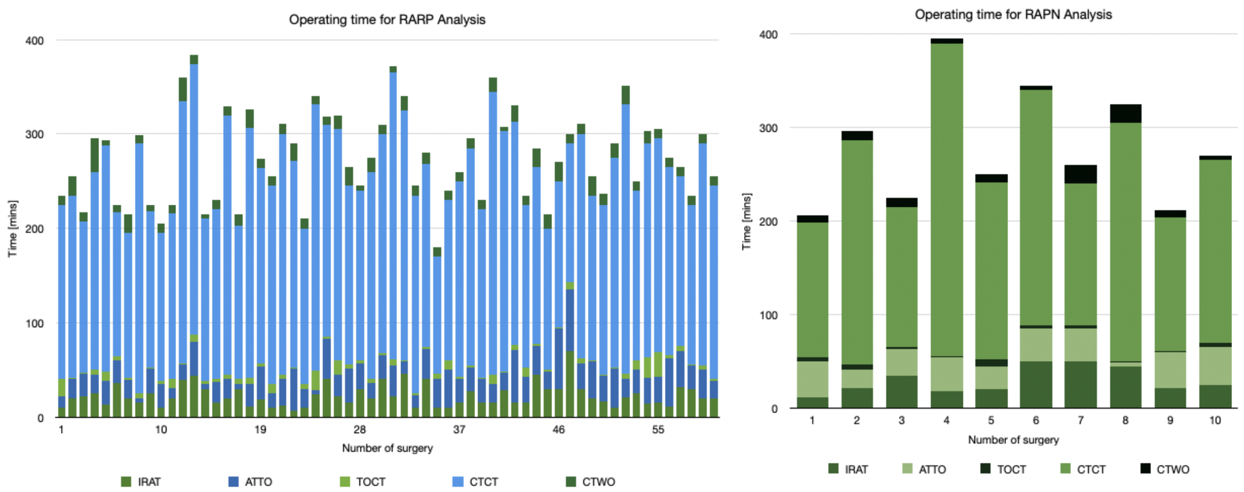

Figure 4. OR time distribution over all phases for RARP and RAPN

Considering the fixed vs variables OR times (see Figure 5), it is easy to remark that almost the third from the total surgical time is filled with non-procedural steps. The median value for fixed OR times is equal to 24,09 % for RARP and 27.36% for RAPN. It is important to mention that comparing to the state of the art (Geldmaker, et al. 2022), our fixed OR times values are improved and this fact may be due to the high level of experience of the surgical team, the pre-anaesthesia room which is often used for intubation and catheters and the fact that at the end of the surgery, in order to wake up the patient, he is transferred to the ICU. This way, the fixed OR times are lowered.

Regarding the moment of the day when the surgeries are performed, most of them are in the afternoon. The reference moment is the first incision moment. Considering the AM/PM timing, 49 of the RARP (82%) started in the second part of the day, only 11 (18%) cases started in the morning. For RAPN, 4 patients (40%) had surgeries in the morning and the other 6 in the evening (60%). This analysis cannot be considered as significant as the others, because depends on the slot availability for the OR and on the surgeon's schedule, at the same time.

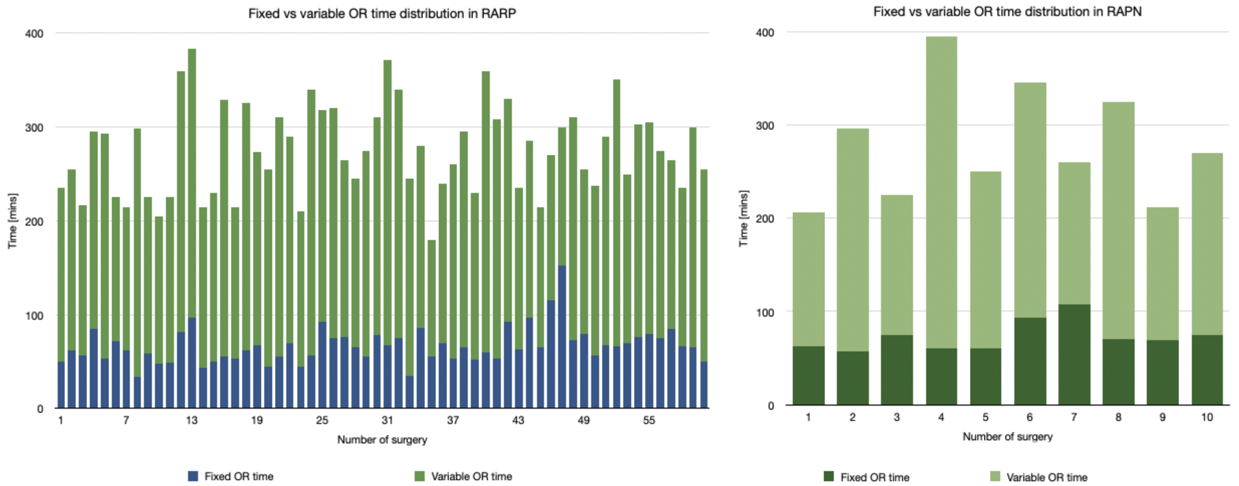

Figure 5. OR time distribution – fixed vs variable OR time

5 CONCLUSIONS

Some key factors that influence the duration of robotic surgeries involve patient-related factors, surgeon proficiency, team dynamics, and technical considerations. Regarding the patient characteristics, the most important aspects are complexity of the surgical procedure required, patient's overall health status and comorbidity, anatomical variations that may affect access and manoeuvrability during surgery.

OR staff has also an important influence over the time management before and during surgery. Some ideas involve effectiveness of team roles and responsibilities allocation, use standardised protocols and checklists for preoperative setup and intra-operative workflow, coordination and communication. Technical aspects should also be considered: setup time for robotic system docking and instrument setup, integration of ancillary equipment, such as energy devices or additional instruments, availability and functionality of backup equipment in case of technical issues.

To address these challenges and maximise the benefits of the da Vinci robotic system, healthcare facilities can adopt several strategies:

- Developing tailored scheduling strategies that account for the added setup and takedown times, as well as the learning curve associated with robotic surgeries.
- Investing in comprehensive and ongoing training for OR staff to ensure a pool of personnel proficient in robotic surgery procedures, reducing dependency on a few individuals.
- Standardising setup and takedown processes and exploring ways to reduce preparation time without compromising safety or system performance.

Understanding and addressing these factors can help surgical teams and healthcare institutions optimise OR time management during robotic-assisted surgeries, ultimately leading to improved patient outcomes and increased efficiency.

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