Review Article

Building up an effective robotic liver surgery team: who do we need?

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Abstract: The role of minimally invasive liver surgery is evolving and expanding to include major hepatectomies in addition to less extensive resections. Both laparoscopic and robotic-assisted methods are being utilized. Advantages of robotic-assisted surgery include improved visualization and ergonomics. A successful robotic surgery program relies on the creation of a strong team both inside and outside of the operating room and allows for efficient and safe patient care. In addition to the clinical and technical expertise needed to perform complex liver operations, all members of the operating room team must have the knowledge to troubleshoot some of the unique technical issues and complications encountered when using the robotic surgical platform. The intra-operative team consists of dedicated anesthesiologists, circulating nurses and surgical technicians with specialized training in liver and robotic-assisted surgery, allowing for safe implementation of a robotic hepatic surgery program.

Keywords: hepatic resection; liver surgery; robotic surgery; operating room teams

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Introduction

Hepatic surgery was revolutionized by the understanding of the segmental anatomy of the liver and implementation of anesthetic techniques that allowed for the performance of safe procedures in a reproducible manner (1). Improvements in preoperative optimization and patient selection, intra-operative monitoring, and postoperative care have led to better clinical outcomes with reduction in both morbidity and mortality rates associated with liver resections (2). More recently, there has been an increase in the utilization of minimally invasive liver surgery, initially limited to minor resections, but currently being applied with increasing frequency to include formal hemi-hepatectomies as well as extended resections (3-5). The first laparoscopic liver resection was reported in the 1990s but its application and widespread use was initially limited (5,6). The Louisville Statement in 2008 first defined acceptable indications for laparoscopic liver surgery to solitary lesions less than 5 cm in segments two to six (7). Advances in techniques and comfort level in experienced hands allowed the indications for minimally invasive approaches to expanded while consistently demonstrating its safety (8). Several consensus conferences have been held since, with updates stating that minor laparoscopic liver resections already represent standard practice; however, they also state that major liver resections should still be considered innovative procedures that require significant expertise (9,10). The most recent iteration came in 2017 at the European Guidelines Meeting on Laparoscopic Liver Surgery held in Southampton,

which again emphasized minimally invasive approach for minor hepatectomies as standard of care with comparable or improved outcomes in regard to hospital length of stay, blood loss, transfusion rate, operation times and recurrence rates (10). The consensus statement included that in major hepatectomies the laparoscopic approach should be reserved for experienced practitioners in selected patients and these approaches should be further developed in major liver centers. Minimally invasive liver surgery provides many of the same benefits of minimally invasive surgery on other organ systems, including reduced postoperative pain and decreased length of stay (8,11). The laparoscopic approach to the liver is challenging with a learning curve of approximately 60 cases (12).

The visual and ergonomic challenges of laparoscopic surgery have played a major role in the development of the robotic surgical platform which allows surgeons to perform advanced laparoscopic procedures with greater ease (13). The da Vinci Surgical System (Intuitive Surgical, Inc, Sunnyvale, CA, USA) is the only commercially available system approved at this time for intra-abdominal robotic surgery, but several other systems are in active development and will be available in the near future. Advantages over laparoscopy include articulating instruments, three-dimensional view of the operative field, and elimination of physiologic tremor (14). Disadvantages include the high cost of initial purchase and maintenance, lack of haptic feedback, difficulty in multi-quadrant procedures, and the need for a skilled bedside assistant. As the platforms continue to develop some of these disadvantages are being addressed and may not pose a hinderance in the future.

Components of a successful robotic liver surgery team

The foundation for these innovations and techniques lies in identifying the essential building blocks to create a robotic team in the operating room, so as to facilitate resolution of errors and operative challenges encountered during hepatic resections. The key components of a successful robotic surgery program in general, and liver program specifically, include a dedicated surgical team, anesthesia team, and operating room staff, including nurses and certified surgical technicians.

It is well established that a robotic operating room team is essential in creating an effective program. This begins with good leadership in the operating room in the form of a competent surgeon. The surgeon should be adept at hepatic surgery from an open perspective prior to attempting to engage in minimally invasive techniques. A strong foundation in general laparoscopic and robotic surgery is strongly advised prior to attempting minimally invasive hepatic resections. If a surgeon's robotic experience is minimal, a formal training program offered through Intuitive Surgical allows for structured exposure and development of a solid foundation in basic skills and knowledge of the robotic platform (15). During these formal training programs surgeons should be connected with a surgical mentor who can provided guidance both in and out of the operating room as the surgeon begins to establish the program. Having two operating consoles in the operating theater is also initially of benefit as this allows the surgeon and a mentor or co-surgeon to work in concert to expedite learning. As noted previously, the learning curve for minimally invasive hepatic resections is approximately 60 cases (12) and skills should be developed in a stepwise fashion. The robotic approach should initially be utilized for minor hepatectomies and straightforward cases until the operating room team has the opportunity to become familiar with the routine and tendencies of the surgeon. With this approach, case complexity should increase gradually over time. In general, attempts to take on complex cases in the setting of surgeon and staff inexperience exposes patients to increased operative risks and increased conversion rates, and can result in stagnation of robotic program development. Grading systems have been developed for minimally invasive hepatectomy to assist the surgeon to determine the difficulty of a case and as a result the most appropriate surgical approach based on experience to safely and efficiently perform the resection (16). Surgeons should be realistic and have clear expectations about the feasibility of a minimally invasive case. When conversion to an open procedure is deemed necessary, it should not be viewed as a failure but rather an expected outcome to promote patient safety during certain cases. Lastly, the surgeon should become comfortable and confident in her/his ability to use the robotic platform effectively and have a basic understanding of troubleshooting should issues arise. In addition, to a competent lead surgeon, it is paramount to have a skilled bedside assistant. When attempting to initiate a robotic program, it is beneficial to have a second surgeon at bedside to assist with inflow control, clip and staple applications, and open access, should complications arise. This is not always sustainable in the long term, and once the program has been established, the bedside assistant role can transition to certified surgical technicians, advanced

practice providers, or certified surgical first assistants as appropriate, based on lead surgeon's experience and the technical challenges of specific cases.

As demonstrated from data generated in laparoscopic surgery research, dedicated staff with indepth understanding and familiarity with the equipment required to perform the operations, not only enhances team competency but also improves efficiency and safety (17). The focus should be on maintaining a dedicated and small team that has the opportunity to work together consistently. Communication remains a difficult hurdle to overcome in the operating room and can result in both safety events and inefficiencies (18). This increased opportunity for interaction between the surgeon and operating room staff can promote a culture of open communication due to familiarity and trust. At the same time, familiarity and improved exposure for the staff, allows them to develop an understanding of surgeon and case routines with improved efficiency and response times should acute issues arise. It has been purposed that nearly a quarter of intra-operative errors are the result of technological failures. Therefore, a dedicated training program for support staff is highly encouraged (19). The Society of American Gastrointestinal and Endoscopic Surgeons and the Minimally Invasive Robotic Association released a consensus document which targeted this very issue and focused on credentialing to ensure patient safety through proper training (14). The preparation to perform robotic surgery was segmented into technical training, which included the knowledge and skills necessary to work the robotic equipment applicable for all team members, and clinical application, which focused on the technical capability of the surgeon to perform the procedures. There are training programs offered by several organizations that allow for certification of staff in robotic platform use and familiarity with troubleshooting techniques in the event of a malfunction. These programs include online modules and training videos with the additional benefit of hands on experience via group seminars to work on team building activities. It should not be overlooked that all staff should be comfortable and confident in performing open hepatic procedures, should the need to convert to an open procedure arise. The ability of the operating room staff to convert a robotic case to an open one is time sensitive and should be accomplished in a controlled manner. Lastly, it cannot be emphasized enough that a circulating nurse and surgical technician who are familiar with patient safety issues specific to minimal access surgery along with the robotic equipment is paramount to maintaining a streamline process that minimizes the possibility of errors as well as the time to recover should they occur.

The final component to an optimized robotic liver surgery program is a consistent anesthesia team familiar with the principles of hepatic resection as well as minimally invasive surgery. Additionally, open communication is essential to allow for effective teamwork within the operating room. The presence of dedicated staff allows for improved familiarity and understanding of preferences which allows for an expeditious response to problems should they arise and ability to raise concerns without hesitation.

Minimally invasive hepatic surgery can pose a challenge for perioperative management. In addition to the potential for significant blood loss, there are several physiologic derangements that can result from pneumoperitoneum that the anesthesia team must understand and contend with during their care of the patient (20-22). Some of these physiological changes include hypercarbia, reduced functional residual lung capacity, bradycardia, and decrease renal function. Maintaining a low central venous pressure (CVP) has become standard practice for liver surgery with the reported benefit of reduced blood loss. To date there is no standard method to achieve this and meta-analysis of several studies does confirm decreased intraoperative blood loss, but this was not shown to translate to improved postoperative morbidity (23,24). Low CVP remains the standard practice but future studies will need to determine the optimal method to achieve this with proven benefit in morbidity and mortality. In the setting of robotic hepatectomy, the CVP is lowered by the physiologic effects of pneumoperitoneum, and the increased intraabdominal pressure is thought to play a role in improved hemostasis at the surgical hepatic margin. A knowledgeable anesthesia team is paramount in the perioperative care of these patients and a necessity should hemodynamic compromise result from intraoperative blood loss requiring resuscitation.

While the operating room staff are key to successful completion of the case, it remains clear that staff familiar with postoperative care is a critical component of a patient's recovery and ultimate discharge. Numerous groups have developed enhanced pathways of recovery for hepatic resection patients built on the groundwork established by the colorectal surgery community. Enhanced recovery pathways require commitment at numerous levels of care, including outpatient education, preoperative medication dosing, intra-operative optimization of anesthesia delivery and fluids, as well as a dedicated team of nurses and therapy

staff who aid the patient's recovery and return to function. These pathways have been shown to decrease times to discharge with improved overall patient satisfaction with comparable morbidity and mortality outcomes (25,26).

In conclusion, a successful robotic liver surgery program relies on numerous layers of support. A comprehensive training program for all staff members involved is critical to safe implementation. Success relies on numerous healthcare specialties and providers working together under the leadership of a surgeon, with the unified goal of developing a team approach that relies on a strong knowledge base and experienced skillset to perform these complex cases in a safe and efficient manner.

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