Review

Robotic Cholecystectomy advantages and disadvantages, a literature review

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Robotic Cholecystectomy Advantages and Disadvantages, A Literature Review

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Abstract: Robotic surgery is a rapidly developing and evolving surgical technique. This literature review evaluates the advantages and disadvantages in the context of gallbladder disease comparing robotic Cholecystectomy to the well-established laparoscopic Cholecystectomy. Significant advantages are reduced operative blood loss, hospital stays and post operative pain, alongside increased patient satisfaction and improved visualisation and precision compared to the laparoscopic approach. Disadvantages include lack of tactile feedback, significant cost attributed to equipment, training requirements and increased procedural time due to the set-up sequences. The implementation of robotic surgery also poses significant changes for the training of future surgeons. Whilst it can standardise training and increases opportunity for simulation, the concern is the loss of traditional skills. Currently the evidence base remains mixed however the use of robotics in the right setting, with suitably trained operatives and appropriate patients can enable improved outcomes for patients with gallbladder disease. There is a lot of scope for development including the implementation of tactile feedback to aid operative technique and artificial intelligence to aid patient safety. Likely broadening the use and potential benefit of robotic surgery not only for cholecystectomy but many surgical specialities.

Keywords: Robotic; Laparoscopic cholecystectomy; tactile feedback; Minamily invasive; Cost effectiveness

Introduction

Robotic surgery is a rapidly evolving surgical technique that has been adopted by many specialities, early robots were used in orthopaedic surgery and early research was driven by military medicine. Robotics are now being utilised in many subspecialities including urology, otolaryngology, general surgery including the topic of this paper hepato-pancreatico-biliary [1]. Currently the majority of surgical robots used are 'master-slave' meaning they are exclusively at the command of the operative surgeon; however future robots may incorporate artificial intelligence meaning they can both learn and aid or perform tasks independently [2].

Although Laparoscopic approach has been established as the optimal approach for cholecystectomy in the majority of circumstances [3], robotic Cholecystectomy has been suggested as an alternative to Laparoscopic Cholecystectomy for the treatment of gallbladder diseas e [4].

The use of robotic technology in cholecystectomy compared to the traditional laparoscopic approach has shown potential benefits, including improved visualization and precision [5], reduced operative time and blood loss [6], and most importantly hospital stay [7]. Robotic surgery is a leap in the development of surgical techniques, but the cost-effectiveness over conventional surgery is still controversial.

In recent years, there has been a growing interest in robotic cholecystectomy as a viable option for the treatment of gallbladder disease [4]. This review seeks to explore the potential advantages and disadvantages of robotic cholecystectomy in comparison to laparoscopic techniques and highlight areas where future development is expected.

Clinical Benefits and drawbacks of Robotic Cholecystectomy

The robotic system provides significant advantages over the traditional multiport and the single port cholecystectomy in terms of procedure and outcomes. These include the following:

Improved Visualization and Precision

Robotic cholecystectomy allows for three-dimensional visualization of the surgical field and the use of high-definition cameras, which can provide better visualization and precision compared to traditional laparoscopic cholecystectomy. The robotic arms also allow for greater dexterity and control of the surgical instruments, allowing for more precise movements and dissection [5].

Reduce operative time and Blood Loss

Several studies have shown that robotic cholecystectomy can result in shorter operative times and reduced blood loss compared to traditional laparoscopic cholecystectomy. For example, a recent meta-analysis of 10 randomized controlled trials (RCTs) found that robotic cholecystectomy had a significantly shorter operative time and lower estimated blood loss than laparoscopic cholecystectomy [6].

Reduced Hospital Stay:

Robotic cholecystectomy has also been associated with a reduced length of hospital stay compared to traditional laparoscopic cholecystectomy. A systematic review and meta-analysis of 21 studies found that robotic cholecystectomy was associated with a shorter hospital stay than laparoscopic cholecystectomy [7].

Less Postoperative Pain and improved satisfaction:

Postoperative pain is a common concern for patients undergoing cholecystectomy. Several studies have evaluated the effect of robotic cholecystectomy on postoperative pain compared to traditional laparoscopic cholecystectomy. A meta-analysis of 12 RCTs found that patients who underwent robotic cholecystectomy had significantly less postoperative pain compared to those who underwent conventional laparoscopic cholecystectomy [8]. Similarly, a study comparing robotic cholecystectomy with single-incision laparoscopic cholecystectomy (SILC) found that patients who underwent robotic cholecystectomy had significantly lower pain score postoperatively. The study reported a lower visual analog scale (VAS) score for pain at 6 hours and 24 hours postoperatively in patients who underwent robotic cholecystectomy [9]. Another study published in 2017 where a total of 102 patients were divided into 2 groups, one scheduled for laparoscopic 3 ports cholecystectomy, and the other for single port robotic cholecystectomy, showed a significant difference in postoperative pain and therefore patient satisfaction and hospital stay in favour of robotic cholecystectomy over conventional 3-port laparoscopic cholecystectomy [10]. These findings suggest that robotic cholecystectomy may result in less postoperative pain compared to 3-port laparoscopic cholecystectomy or SILC. The potential reduction in postoperative pain can lead to improved patient comfort and satisfaction following surgery.

Overall, the use of robotic technology in cholecystectomy has shown potential benefits in terms of improved visualization and precision, blood loss, and hospital stay. These benefits can lead to improved outcomes and faster recovery for patients undergoing cholecystectomy.

Drawbacks and Disadvantages of Robotic Cholecystectomy

Despite the potential benefits, robotic cholecystectomy also has some drawbacks compared to traditional laparoscopic cholecystectomy including:

Lack of tactile feedback:

It is noticeable that robotic technique improves visualization and precision, eliminates fulcrum effect and allows for higher dexterity, therefore better control, however, the absence of the tactile feedback, may impair the surgeon's ability to detect tissue texture, tension, and depth perception [11]. This may increase the risk of injury to biliary tree in certain situations, which is a serious complication of cholecystectomy [12].

High cost:

One of the main limitations is the high cost associated with the use of robotic technology, overall hospital costs were significantly higher for robotic-assisted cholecystectomy compared to laparoscopic cholecystectomy, these are mainly acquisition, consumables and maintenance costs of the robotic system [13]. In addition, robotic cholecystectomy requires specialized equipment, and staff training, which may limit its availability in some hospitals.

Longer operative time:

Robotic cholecystectomy requires longer operative and setup time compared to traditional laparoscopic cholecystectomy, which may increase the risk of anaesthesia-related complications and delay patient recovery [14].

These limitations and disadvantages suggest that robotic cholecystectomy may not be suitable for all patients and hospitals, and that careful patient selection and training of surgical teams are crucial for the safe and effective use of robotic technology in cholecystectomy.

Future Directions

Despite the limitations and disadvantages of robotic cholecystectomy, the technology continues to evolve and improve. One potential direction for future development is the incorporation of augmented reality and haptic feedback into robotic surgery systems, which could enhance the surgeon's perception of tissue properties and improve precision and safety [15].

Another promising area of research is the use of artificial intelligence and machine learning algorithms to improve surgical outcomes and efficiency [16]. For example, machine learning models could be trained to predict patient outcomes and complications based on preoperative and intraoperative data and provide real-time guidance and feedback to the surgeon [17].

Furthermore, the integration of robotic surgery with other technologies such as imaging, navigation, and telemedicine could enable remote surgical procedures and enhance collaboration and education among surgeons [18,19].

As the field of robotic surgery continues to expand and evolve, it will be important to evaluate the clinical outcomes and cost-effectiveness of different robotic cholecystectomy systems and techniques, and to ensure that patient safety and well-being remain the top priority.

Impact on Training the Next Generation of Surgeons

The adoption of robotic cholecystectomy has not only changed the landscape of surgical practice but also has an impact on surgical training. As more surgeons are trained in robotic surgery, it is important to evaluate the impact of robotic technology on the education and training of the next generation of surgeons.

One potential advantage of robotic cholecystectomy for surgical training is that it provides a more structured and standardized approach to surgical procedures. Robotic surgery systems often incorporate simulation modules and training programs that allow trainees to practice and develop their skills in a safe and controlled environment [20]. This can lead to a more efficient and effective training process and may potentially reduce the learning curve for new surgeons.

However, there are also concerns that the adoption of robotic surgery may lead to a decrease in traditional surgical skills, such as manual dexterity and spatial awareness [21]. In addition, the high

cost and complexity of robotic surgery systems may limit the availability of training opportunities for surgical trainees, particularly in resource-limited settings [22].

It is therefore important for surgical training programs to strike a balance between incorporating the benefits of robotic technology while maintaining the importance of traditional surgical skills. Moreover, there needs to be a continued effort to develop affordable and accessible training programs and resources that incorporate robotic surgery technology.

Discussion

Robotic cholecystectomy has become increasingly popular in recent years due to its many potential advantages over traditional laparoscopic cholecystectomy. It offers a more precise and controlled approach, improved visualization of the surgical field [5], reduced operative blood loss [6], shorter hospital stays [7] and reduced post operative pain [8,9]. It has been shown to be safe and effective in the treatment   of gallbladder disease, with low rates of complications and high patient satisfaction [10].

However, as with any surgical technique, robotic cholecystectomy is not without drawbacks and disadvantages. One major disadvantage is the high cost of the robotic surgery system, which limits its availability in many healthcare settings [13]. Additionally, the lack of tactile feedback and the learning curve associated with the use of robotic technology may result in longer operative times and increased rates of complications in the hands of less experienced surgeons [11,14].

Another important consideration is the impact of robotic cholecystectomy on postoperative pain. While some studies have shown that robotic cholecystectomy may result in less postoperative pain compared to traditional laparoscopic cholecystectomy, the evidence is mixed, and further research is needed to fully elucidate this relationship.

The impact of robotic cholecystectomy on surgical training is another important consideration. While robotic surgery technology can provide a more structured and standardized approach to surgical procedures, there are concerns that it may limit the development of traditional surgical skills such as manual dexterity and spatial awareness [21], furthermore there is concern about accessibility and equality of training due to high cost of equipment and lack of potential of lack of services in certain areas [22].

It is therefore important for surgical training programs to strike a balance between incorporating the benefits of robotic technology while maintaining the importance of traditional surgical skills.

Looking forward, there are several potential future directions for robotic cholecystectomy. One potential area of development is the incorporation of artificial intelligence and machine learning algorithms to enhance the precision and accuracy of surgical procedures [4]. Furthermore, continued efforts to improve the accessibility and affordability of robotic surgery technology will be important in ensuring that its benefits are available to a broader range of patients and healthcare providers.

In conclusion, robotic cholecystectomy represents a promising advancement in the field of minimally invasive surgery. While there are drawbacks and limitations to its use, its potential benefits make it an important technique to consider in the treatment of gallbladder disease. Further research is needed to fully elucidate the impact of robotic technology on surgical outcomes, training, and the overall landscape of surgical practice.

Conclusion

Robotic cholecystectomy is a rapidly evolving field that has shown significant potential in improving patient outcomes and reducing healthcare costs. The clinical benefits of robotic cholecystectomy include reduced operative times, decreased blood loss, shorter hospital stays, and lower rates of postoperative complications. Additionally, patients report higher satisfaction with their surgical experience when undergoing robotic cholecystectomy compared to traditional laparoscopic surgery.

However, there are also several drawbacks and disadvantages associated with robotic cholecystectomy, including higher costs, longer learning curves, and technical limitations.

Furthermore, the impact of robotic cholecystectomy on postoperative pain remains uncertain, and further research is needed to clarify its potential benefits in this area.

Despite these challenges, the future of robotic cholecystectomy is promising, with potential developments in artificial intelligence and machine learning, virtual and augmented reality, and improved accessibility and affordability. These advances could further enhance the precision, safety, and efficiency of surgical procedures, ultimately leading to better patient outcomes and reduced healthcare costs.

In conclusion, robotic cholecystectomy represents a valuable addition to the armamentarium of surgical techniques available to treat gallbladder disease. While there are still several challenges to overcome, the potential benefits of robotic cholecystectomy are significant, and further research and development in this area are warranted.

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