Minimally invasive surgery: early concepts to gold standards

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Abstract

Traditionally, surgery of the abdomen and pelvis has been through the open approach. However, with the advent of technological advancements, surgical specialities have embraced the benefits of minimally invasive surgery (MIS), both for the surgeon and the patient.

With the early concepts of MIS dating as far back as 400 BC, and with the myriad of technological advancements, refinements in MIS has allowed patients to benefit from quicker recovery, convalescence and cosmesis. The many recognised benefits have meant that many procedures recognise MIS as the gold standard, including cholecystectomy, appendectomy and prostatectomy.

However, even with these benefits patient selection remains important. Just because MIS can be performed doesn't mean that it should always be performed, as certain patient groups are contraindicated and the need to convert to an open procedure loses all associated benefits of MIS.

Acknowledgement

AN would like to thank The Royal College of Surgeons of England for their RCS Intercalated Bachelor of Science Degree in Surgery Award 2019.

Conflict of interest statement

None.

Introduction

Traditionally, surgery of the abdomen and pelvis has been through the open approach. However, with the advent of technological advancements, surgical specialities have embraced the benefits of minimally invasive surgery (MIS), both for the surgeon and the patient.

History of minimally invasive surgery

The first successful elective laparotomy was performed in 1809 by Ephraim McDowell to resect a 10.2 kg ovarian tumour (Ellis 2015). Since then, open surgery, or a laparotomy of the abdomen, has remained the gold standard for many procedures, such as open nephrectomy for the management of small renal masses (2005).

The early concepts of MIS originate as far back as Hippocrates, where in 400 BC, he detailed the use of a speculum to examine haemorrhoids (St. Peter and Holcomb 2008). The 19th century saw further developments at a light source, with Bozzini's *Lichtleiter* (1806), Segalas' *urethro-cystique* (1826) and Nitze's *kystoskop* (1877) (St. Peter and Holcomb 2008). Bernheim reported the first laparoscopy (1911), and since then, there have been a myriad of development in technology and technique: CO_2 insufflation (1910); Veress' spring loaded needle for induction of a pneumoperitoneum (1938); Kalk's 135° lens (1929); Hopkins' fibreoptic prototype (1954); and the Hasson technique for direct visualisation of port placement (1974) (St. Peter and Holcomb 2008). With these advancements, only now could MIS be more widely adopted, to offer patient benefits when compared to the previous standard of a laparotomy.

Current status

There are many procedures where the minimally invasive approach has become the new gold standard, or where it is not, is being used more frequently due to the associated benefits for the patient.

Cholecystectomy is a very common procedure (NHS 2016), and the open approach has been the gold standard for over 100 years, with the laparoscopic alternative introduced in the 1980s (Keus et al. 2006). The National Institute of Health Consensus Development Conference (1992) found laparoscopic cholecystectomy to be preferential to the open technique (Gollan et al. 1993), and is now the gold standard (National Institute for Health and Care Excellence (NICE) 2014). A Cochrane Systematic Review (Keus et al. 2006), comparing laparoscopic and open cholecystectomy for patients with

symptomatic cholecystolithiasis found that there were no significant differences in mortality, complications and operative time between the two techniques, but found that the laparoscopic technique was associated with significantly shorter hospital stay and quicker convalescence.

Open partial nephrectomies (OPN) remain the gold standard in the treatment of small renal masses. Despite this, at Royal Free Hospital, only 8% of all renal operations are through the open approach, and 12% laparoscopically and 80% robotically. This is due to the many associated patient benefits of MIS.

Laparoscopic partial nephrectomy (LPN) has been shown to be as effective as the gold standard (Benidir et al. 2014), by offering comparable long-term oncological and functional outcomes (Cha et al. 2011). LPN is associated with post-operative benefits for the patient (decreased blood loss, shorter length of stay, improved cosmesis and shorter convalescence) (Cha et al. 2011), however its use should be only by a surgeon experienced in the laparoscopic procedure.

Robotic-assisted partial nephrectomy (RAPN) is a relatively new procedure, first described by Gettman et al. in 2004 (Gettman et al. 2004). Like LPN, its minimally invasive approach has many patient benefits. A comparative study between OPN, LPN and RAPN found that RAPN had shorter warm ischaemia time (WIT) than LPN (although the gold standard had the shortest); the lowest estimated blood loss; lower morbidity (intra and postoperative complications) than OPN; and lower rates of positive surgical margins than the gold standard (Porpiglia et al. 2016). In their study, trifecta was defined as the absence of perioperative complications, negative surgical margins and WIT < 25 minutes. They reported that this occurred in 62.4%, 63.2% and 69.0% for OPN, LPN and RAPN respectively, showing that the minimally invasive approaches were functionally and oncologically superior.

Laparoscopic appendectomy has a significantly smaller incision compared to the open approach (Ruffolo et al. 2013). Its minimally invasiveness, in a recent Cochrane Systematic Review (Sauerland et al. 2010), was shown to be associated with reduced postoperative pain, reduced wound infection rate and a shorter time until return to normal activity, as well as better cosmesis. Minimally invasive surgery offers clear advantages and should be preferred in obese patients, older patients and patients with comorbidities (Di Saverio et al. 2016), which would make them poorer candidates for maximally invasive (open) surgery, which is often due to a reduced physiological reserve to recover from surgery.

Open radical prostatectomy has been the traditional approach (Ilic et al. 2017), but robotic assisted radical prostatectomy (RARP) has now become the gold standard in the treatment of localised prostate cancer (Mottet et al. 2015). A recent Cochrane Systematic Review (Ilic et al. 2017) found that laparoscopic radical prostatectomy and robotic assisted radical prostatectomy were similar to the gold standard in terms of urinary and sexual quality of life-related outcomes, and that differences in postoperative pain was minimal, but found that the minimally invasive approach had shorter length of stay and less blood loss when compared to the gold standard.

When comparing a laparotomy to MIS, a large incision in the abdominal wall is replaced by several smaller incisions. This offers the patient better cosmesis, and though there may be a greater number of incisions, there has been development towards single port surgery (single incision laparoscopic surgery (SILS) and the Da Vinci SP (Intuitive Surgical, Inc, Sunnyvale, Calif)) ([CSL STYLE ERROR: reference with no printed form.]), or even hidden incisions (natural orifice transluminal endoscopic surgery (NOTES)).

Benefits to the patient

The many patient benefits associated with MIS, when compared to a laparotomy are due to the minimally invasive nature of the procedure. With smaller wounds, the patient can recover quicker, and achieve quicker convalescence, as shown by the Cochrane review for cholecystectomy. In the case of RAPN, it has even been shown to offer superior oncological outcomes when compared to the gold standard, and the significance of decreased WIT allows for preservation of functional renal parenchyma, improving the patient's functional outcomes, alongside the associated decrease in total morbidity. Within appendectomy, the laparoscopic approach has been shown to be associated with reduced postoperative pain, reduced wound infection rate and a shorter convalescence, and is even preferred for patients who are poorer candidates for open surgery. With regards to radical prostatectomies, whilst achieving similar results to the gold standard in terms of urinary and sexual quality of life-related outcomes, the patient benefits from shorter length of stay and blood loss.

Limitations of minimally invasive surgery

There are certain contraindications to the use of MIS. Patients with physiological limitations (Bowers and Hunter) are poor candidates for MIS. Patients with severe hypovolaemia may not compensate well

and may experience a large fall in cardiac output following insufflation. The Trendelenburg position and insufflation can also increase intracranial pressure (ICP), and is therefore contraindicated in patients with an already elevated ICP, and in those with glaucoma

The patient benefits of MIS can be lost when there are laparoscopic entry access injuries. A study looking at claims arising from US and non-US entry access injuries (Chandler et al. 2001), found that the most commonly reported injuries were that to the small bowel and iliac artery. With any form of internal injury, such as an uncontrolled rate of bleeding, and the limited accessibility through the minimally invasive nature, there will be times when there is a need to convert to a laparotomy. As such, the patient loses all associated benefits of MIS once this is performed. So, whilst MIS offers many potential benefits, it is important for the surgeon to consult the patient about the associated risks as well, and the potential need to convert to an open procedure.

As MIS is relatively new, compared to the pre-existing gold standard laparotomy in many procedures, long-term follow up will be required to effectively prove that the new minimally invasive approaches are able to offer superior oncological outcomes (in the case of cancer) when compared to the current gold standard. This is because most MIS procedures have already been shown to be safe and feasible as they can be performed, and they have already shown, even in early findings, to offer superior functional outcomes to a laparotomy.

Conclusion

The benefits of performing MIS over a laparotomy is that often, equal oncological outcomes are achieved, whilst achieving superior functional outcomes, which means that the patient is able to gain more from the procedure. Even with these benefits, patient selection still remains important in ensuring that the patient will benefit as much as they can from the MIS. Just because MIS can be performed does not mean that it should be performed on all patients, as outlined by the potential limitations of MIS in certain patient groups and the associated risk of complications. Overall, for many patients, MIS is beneficial compared to laparotomy, especially with regards to superior functional outcomes post-op.

Keywords

Minimally invasive surgery; laparoscopic surgery; robotic surgery; history of minimally invasive surgery; patient benefits

References

Benidir T, de Castilho TJC, Cherubini GRL, de Almeida Luz M, de Almeida Luz M. 2014. Laparoscopic partial nephrectomy for renal cell carcinoma in a horseshoe kidney. J Can Urol Assoc. 8(11-12 DECEMBER):918–920. doi:10.5489/cuaj.2289.

Bowers SP, Hunter JG. Contraindications to Laparoscopy. In: The Sages Manual. p. 25–32.

Cha EK, Lee DJ, Del Pizzo JJ. 2011. Current status of robotic partial nephrectomy (RPN). BJU Int. 108(6 B):935–941. doi:10.1111/j.1464-410X.2011.10556.x.

Chandler JG, Corson SL, Way LW. 2001. Three Spectra of Laparoscopic Entry Access Injuries.

Ellis H. 2015. The First Successful Elective Laparotomy. J Perioper Pract. 25(10):207–208. doi:10.1177/175045891502501005.

Gettman MT, Blute ML, Chow GK, Neururer R, Bartsch G, Peschel R. 2004. Robotic-assisted laparoscopic partial nephrectomy: Technique and initial clinical experience with daVinci robotic system. Urology. 64(5):914–918. doi:10.1016/j.urology.2004.06.049.

Gollan JL, Bulkley GB, Diehl AM, Elashoff JD, Federle MP, Henderson JM, Hogan WJ, Kelly KA, Massanari DL, Powell DW, et al. 1993. National Institutes of Health Consensus Development Conference Statement: Gallstones and Laparoscopic Cholecystectomy. September 14-16, 1992. J Laparoendosc Surg. 3(1):77–90.

Ilic D, Evans SM, Allan CA, Jung JH, Murphy D, Frydenberg M. 2017. Laparoscopic and robotic-assisted versus open radical prostatectomy for the treatment of localised prostate cancer. Cochrane Database Syst Rev. 2017(9). doi:10.1002/14651858.CD009625.pub2.

Intuitive Surgical | System | da Vinci SP| Single Port. [accessed 2019 Feb 5]. https://www.intuitive.com/en/products-and-services/da-vinci/systems/sp.

Keus F, De Jong JAF, Gooszen HG, Van Laarhoven CJHM. 2006. Laparoscopic versus open cholecystectomy for patients with symptomatic cholecystolithiasis. Cochrane Database Syst Rev.(4). doi:10.1002/14651858.CD006231.

Laparoscopic nephrectomy (including nephroureterectomy). 2005.

Mottet N, Bellmunt J, Briers E, van den Bergh R, Bolla M, Casteren N, Cornford P, Culine S, Joniau S, Lam T, et al. 2015. Guidelines on prostate cancer.

National Institute for Health and Care Excellence (NICE). 2014. Gallstone disease: diagnosis and management | Guidance and guidelines | NICE. [accessed 2019 Jan 30]. https://www.nice.org.uk/guidance/cg188/chapter/1-recommendations.

NHS. 2016. Gallbladder removal - NHS Choices. :4.

St. Peter SD, Holcomb GW. 2008. History of Minimally Invasive Surgery. Elsevier Inc.

Porpiglia F, Mari A, Bertolo R, Antonelli A, Bianchi G, Fidanza F, Fiori C, Furlan M, Morgia G, Novara G, et al. 2016. Partial Nephrectomy in Clinical T1b Renal Tumors: Multicenter Comparative Study of Open, Laparoscopic and Robot-assisted Approach (the RECORd Project). Urology. 89:45–51. doi:10.1016/j.urology.2015.08.049.

Ruffolo C, Fiorot A, Pagura G, Antoniutti M, Massani M, Caratozzolo E, Bonariol L, Di Pinto FC, Bassi N. 2013. Acute appendicitis: What is the gold standard of treatment? World J Gastroenterol. 19(47):8799–8807. doi:10.3748/wjg.v19.i47.8799.

Sauerland S, Jaschinski T, Neugebauer EA. 2010. Laparoscopic versus open surgery for suspected appendicitis. In: Cochrane Database of Systematic Reviews. John Wiley & Sons, Ltd.

Di Saverio S, Birindelli A, Kelly MD, Catena F, Weber DG, Sartelli M, Sugrue M, De Moya M, Gomes CA, Bhangu A, et al. 2016. WSES Jerusalem guidelines for diagnosis and treatment of acute appendicitis. World J Emerg Surg. 11(1):34. doi:10.1186/s13017-016-0090-5.