10 Principles of minimal access surgery

Analgesia

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The type and extent of analgesic requirement will depend on both the patient and procedural factors. Prior experience of opiate analgesia may increase patient tolerance to similar agents, necessitating larger doses. There is also evidence to suggest that those patients struggling with chronic pain preoperatively often present a more complex postoperative analgesic problem. The extent and region of surgery will also dictate the analgesic regimen. For example, even mini mal access thoracic surgical procedures commonly require patient-controlled opiate analgesia with or without local nerve blockade (intercostal or paravertebral) in the initial 48 hours after surgery . T his may be avoided for some abdominal surgery by careful use of non-steroidal agents and paracetamol. Opiate analgesics cause nausea, impair gut motility and should be avoided unless the pain is very severe. When pain is dispropor tionate to the presenting problem, suspect a complication (see also Chapter 23). Analgesia

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The discharge of patients is based on clinical indicators and the patient’s fitness for recuperating in a non-hospital environ - ment. One of the core drivers for the application of minimally invasive surgery is an earlier recovery and therefore discharge from hospital. Pa tients should not be discharged until they are comfortable, have passed urine and are eating and drinking Principles of minimal access surgery /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF satisfactorily . They should be told that if they develop worsen ing pain or other severe symptoms they should return to the hospital or to their general practitioner. Even for more major cases, some units have demonstrated safe and feasible protocols for a 23-hour stay .

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In addition to the remote master–slave platform design, direct robot systems also exist. Each of these systems o ﬀ ers di ﬀ erent advantages to the operating surgeon, ranging from reducing the need for assistants and providing better ergonomic operating positions to providing experienced guidance from surgeons not physically present in the operating theatre. Examples include: /uni25CF tremor suppression robots; /uni25CF active guidance systems; /uni25CF articulated mechatronic devices; /uni25CF force control systems; /uni25CF haptic feedback devices. Direct robotic systems and hybrid robotic surgery

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Cost Robotic surgery remains more costly than minimally invasive alternatives. Through upscaling of use between surgical specialties, the direct costs of purchasing a novel robotic system can be partially o ff set; however, consumable costs remain high. When compared with open techniques, robotic surgical procedures can reduce hospital stay , thus in part o ff setting this expenditure; however, it remains di ffi cult to demonstrate significant improvement in length of stay or clinical outcomes when compared with other minimally invasive alternatives. Another consideration is the increased operating time and overall learning curve requirement when establishing a robotic surgical programme. While some specialties have reported shorter learning curves than in the early days of laparoscopic surgery , this is highly heterogeneous, across both specialties and practitioners. Furthermore, although shared interspecialty

Figure 10.3 Robotic theatre set-up demonstrating the da Vinci Xi sys

tem. The surgeon and trainee surgeon are positioned at joint consoles remote from the operating table with the surgical assistant and scrub nurse at the bedside (courtesy of Mr Tom Routledge, Guy’s and St Thomas’ NHS Foundation Trust, London, UK).

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Endoluminal endoscopy and natural orifice surgery

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Flexible or rigid endoscopes are introduced into hollow organs or systems, such as the urinary tract, upper or lower gastrointestinal tract and the respiratory and vascular systems. Advances in endoluminal technology now enable more complex procedures to be completed endoscopically where previous transabdominal or transthoracic surgical resection would have been advocated. Examples include endoscopic submucosal resection of complex colonic polyps, transanal endoscopic microsurgery and endobronchial laser resection of tracheal pathology . Natural orifice translumenal endoscopic surgery (NOTES) o ﬀ ers the opportunity for ‘scar-free’ surgery by performing entire procedures via natural body orifices. While these tech niques have been applied in the pelvis, abdomen and thorax, technical limitations and safety concerns have limited adop tion. Concern over closure of the visceral puncture site is the principal issue that has prevented widespr ead uptake, as trans gastric and transcolonic closure of peritoneal entry sites in a safe manner remains problematic. In addition, there ar nificant cost and training implications that have limited more widespread adoption. Endoluminal endoscopy and natural orifice surgery

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Many sur - geons feel that endoscopic 3D technology does not yet o ff er the technical enhancement necessary to improve safety . Indeed, - 3D technology has been associated with ergonomic problems - such as headache without quantifiable benefit in terms of accu - racy and time to perform directed tasks. Future improvements in these systems carry the potential to enhance manipulative ability in critical procedures, such as knot tying and dissection of closely overlapping tissues. There are , however, some draw - backs, such as reduced display brightness and interference with normal vision because of the need to wear specially designed glasses for some systems. It is likely that brighter projection displays will be developed; however, the need to w ear glasses is not easily overcome. These factors currently limit stereoscopic straight stick endoscopic surgery , which has largely been super - seded by the development of robotic technology incorporating 3D vision. Minimal access surgery can be more technically demanding and slower to perform than conventional open surgery . On occasion, a minimally invasive operation is so technically demanding that both patient and surgeon would be better served by conversion to an open procedure. Prolonged anaesthetic and operative times may negate a number of the beneficial e ff ects of minimal access surgery and increase the risk of respiratory and wound complications as well as compression neuropathy and venous thromboembolism. It is vital for surgeons and patients to appreciate that the decision to convert to an open operation is not a complication but, instead, usually implies sound surgical judgement in favour of patient safety . Control of bleeding and haemostasis Haemostasis may be di ffi cult to achieve endoscopically because blood may obscure the field of vision with reduced image quality owing to light absorption. 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The future of minimal access surgery will almost certainly feature more advanced applications of adjuncts to facilitate anatomical recognition and the localisation of pathology . These are becoming commonplace in both video-assisted and robotic-assisted procedures. Augmented reality Augmented reality by definition comprises the fusion of projected computerised images with a real environment. In surgery , this involves the application of real-time imaging or other data overlaid via computer processing software onto the surgical field. Such technology may be particularly beneficial in minimal access surgery where the localisation of pathology and identification of anatomy may be more di ffi cult than in open surgery because of the lack of digital palpation of the relevant structures. At an elementary level, examples include the use of indocyanine green for immunofluorescent localisation of tumours as well as vascular, bronchial or lymphatic structures. When bound to plasma proteins, indocyanine green emits light with near-infrared light. Through use of a specifically designed HD camera and software system with imposed pseudo-colour, areas of di ff er ential tissue density and vascular supply can be detected clearly without the need for digital palpation, thus facilitating complete resection and clear surgical margins. Its use is now well established in procedures such as minimal access liver, lung, renal and prostatic resections, and its role in other specialties such as colorectal surgery is also under investigation. The technology can be integrated into both video-assisted and robotic-assisted surgical procedures and is available within ® the da Vinci Xi and X robotic surgical systems as the Firefly mode, which can be turned on as required from the surgical console (Figure 10.7) . - Another role for augmented reality in minimal access sur - gery is the overlay of imaging beside or directly onto the surgi - cal field, ‘navigating’ the surgeon to the site of interest without the need to look away from the patient to review imaging. Such navigational techniques originated in image-guided diagnos - tics, enabling identifica tion of pathology in areas more di ffi cult to reach anatomically . Through increasing adoption of hybrid theatre complexes, these approaches ma y be utilised for both diagnosis and treatment in a single setting. An example is the use of navigational bronchoscopy to identify , diagnose and treat di ffi cult to reach or small lung nodules. Preoperative planning CT scan is reconstructed by specialist software. The result is a 3D ‘road map’ of the bronchial tree and a side-by-side picture of real-time endobronchial images with those from the imag - ing system (Figure

10.8). The surgeon is then guided directly along the airway to the lesion of interest that can be biopsied with on-site frozen section. Where the lesion is resectable but di ffi cult to localise, a fiducial marker may be placed to enable localisation under fluoroscopy guidance in a second-stage pro - cedur e performed in a hybrid theatre (Figure 10.9). Where resection is not possible, ablation or other treatment may be o ff ered in the same setting, both reducing surgical in vasiveness and increasing the provision of curative surgery to patients who may not otherwise be candidates for resection. An area of interest is the application of head-mounted dis - plays and eyeglasses to minimal access surgery . Although the majority of applications remain in the realm of simulation and training, the promise of real-time image guidance by means of multiplanar or imaging over lay of the surgeon’s view is par - ticularly attractive. Head-mounted displays may also provide data display or communication tools, reducing the need for the surgeon to look away from the operative field and allow real-time guidance by a trainer or pr octor. To date, clinical application is limited owing to time lag, the need for high-speed wireless Internet or Bluetooth connection and device weight and battery life; application to minimal access surgery remains under development.

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Many minimal access procedures have a unique set of proce - dural steps that may often be in a distinctly di ff erent sequence from those of the open alternative. Methods for creating a pneumoperitoneum are described in Chapter 7 . Preoperativ e evaluation is necessary to assess the type and location of surgical scars and potential for perivisceral adhesions. In the setting of redo sur gery , trocar insertion may be complex and should be performed by an open approach with direct visualisation on entry to the body cavity (abdomen - gertip helps to ascertain penetration into the body cavity and allows adhesions to be gently removed from the entry site. The endoscopic camera may be used as a blunt dissector to tease adhesions gently awa y and form a tunnel towards the quad rant where the operation is to take place. With experience, the surgeon learns to di ff erentiate visually between thick adhesions that should be avoided and thin adhesions that would lead to a window into a free area. In obese patients the location of some of the ports ma need to be modified and, in some instances, larger and lon ger instruments may be necessary . It is important to recognise this preoperatively to ensure that adequate measures are put in place to ensure safe and e ffi cient surger y when the patient arrives. It is also important to consider the weight and dimen sion restrictions of the operating table. In some cases, specialist operating tables will be required (Chapter 68). GENERAL INTRAOPERATIVE PRINCIPLES

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Hybrid surgery may utilise a combination of flexible and straight stick endoscopic approaches or a combination of open and endoscopic surgery . Totally endoscopic hybrid approach The diseased organ is visualised and treated by an assortment of endoluminal and extraluminal endoscopes and other imaging devices. In the abdomen, examples include the combined laparo-endoscopic approach for the management of biliary lithiasis, colonic polyp excision and several urological procedures, such as pyeloplasty and donor nephrectomy . In the thorax, navigational bronchoscopy with placement of fiducial markers has been employed as a means of marking lung nodules that can then be resected via a minimal access video-assisted approach. Cardiovascular surgeons have - for some time employed hybrid technologies to facilitate catheter-based placement of cardiac valves, atrial devices and - intravascular stents. Hybrid techniques o ff er improved visualisation, facilitating - the primary procedure to be carried out either via a smaller incision or a minimal access approach where otherwise open e sig - surgery would have been necessar y . Such approaches may necessitate the availability of ‘hybrid’ theatre facilities, limit - ing this approach to tertiary centres where such technology is available (Figure 10.1) . Open and endoscopic hybrid approach Hand-assisted laparoscopic surgery (HALS) is a well-developed technique. It involves the intra-abdominal placement of a

Figure 10.1 Modern hybrid theatre set-up (courtesy of Mr Kelvin Lau, Barts Thorax Centre, London, UK).

pneumoperitoneum is maintained. In this way , the surgeon’s hand can be used as in an open procedure. It can be used to palpate organs or tumours, reflect organs atraumatically , retract structures, identify vessels, dissect bluntly along a tissue plane and provide finger pressure to bleeding points, while proximal control is achieved. This approach has been suggested to o ff er technical and economic e ffi ciency when compared with a totally laparoscopic approach, in some instances reducing both the number of laparoscopic ports and the number of instru ments required. Indeed, some advocates argue that if such an incision is necessary for extraction of the final specimen then HALS does not significantly increase surgical trauma over totally laparoscopic approaches. Furthermore, for those trained in open surgery it may be easier to learn and perform than totally laparoscopic approaches, subsequently improving patient safety . With the new generation of surgeons training in totally laparoscopic surgery it is likely that use of HALS will diminish, although it should remain part of the minimally invasive surgeon’s armamentarium.
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(a) (b) Figure 10.6 Use of rolled swabs for retraction of the lung during pulmonary lobectomy (courtesy of Mr Tom Routledge, Guy’s and St Thomas’ NHS Foundation Trust, London, UK).

About half of patients experience some degree of nausea after minimal access surgery . It usually responds to an antiemetic, such as ondansetron, and settles within 12–24 hours. It is made worse by opiate analgesics and these should be rationalised or avoided where at all possible.
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(a) (b) Figure 10.6 Use of rolled swabs for retraction of the lung during pulmonary lobectomy (courtesy of Mr Tom Routledge, Guy’s and St Thomas’ NHS Foundation Trust, London, UK).

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Perivisceral endoscopy

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Body planes can be accessed even in the absence of a natural cavity . Examples are mediastinoscopy , retroperitoneoscopy and retroperitoneal approaches to the kidney , aorta and lumbar sympathetic chain. Some of these approaches have been in place for many years (cervical mediastinoscopy was first performed in 1959); however, the availability of novel videoscopes has enhanced visualisation, thus improving the safety and accuracy of dissection. Extraperitoneal approaches to the retroperitoneal organs, as well as hernia repair, are now commonplace, further decreasing morbidity associated with manipulation of the visceral peritoneum. Other examples include subfascial endoscopic perforator surgery for ligation of incompetent perforating veins in varicose vein surgery and endoscopic harvesting of the saphenous vein for use in coronary artery bypass grafting. Masaki Watanabe , 1911–1995, orthopaedic surgeon, Tokyo, Japan, known as the ‘founder of modern arthroscopy’. - Perivisceral endoscopy

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Port site pain and numbness

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Pain in one or other of the port site wounds is not uncommon and is worse if there is haematoma formation. It usually settles very rapidly . In the case of thoracoscopy , intercostal nerve pain may be more common in those with smaller intercostal spaces. Nerve blockade by means of directed local anaesthesia is e ff ective at reducing pain and the need for opiate medication in the immediate postoperative period. Increasing pain after 2–3 days may be a sign of infection and, with concomitant signs, antibiotic therapy is occasionally required. Occasionally , herniation through a port may account for localised pain and should be considered, particularly if occurring late with a relevant preceding history (e.g. coughing). Failure of a patient to follow the expected recovery pathway should prompt senior review with appropriate imaging and relook surgery if consid ered necessary . Port site pain and numbness

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Preparation of the patient

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Although the patient may be in hospital for a shorter period, - careful preoperative management is essential to minimise morbidity . Recognition of patient- or procedure-related factors that may in turn complicate a minimal access approach is vital to optimise outcomes. History Patients must be fit for general anaesthesia and open operation if necessary . Potential coagulation disorders are particularly dangerous in minimal access surgery where options for haemostasis may be more limited. A prior history of surgical intervention in the same area is vitally important and should be carefully documented, so as to best predict factors such as adhesions that may preclude a minimal access approach. Previous oncological treatment can also create a more hostile surgical environment and an appropriate threshold for conver - sion to open access should be set prior to the procedure and communicated clearly with the patient. Preparation for minimal access surgery /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF Examination Routine preoperative physical examination is required as for any major operation. Although, in general, minimal access surgery allows quicker recovery , it may involve longer operat ing times and carbon dioxide insu ffl ation in both the chest and abdomen may provoke cardiac arrhythmias. Severe chronic obstructive airways disease and ischaemic heart disease may be contraindica tions to a minimal access approach. Moderate obesity does not increase operative di ffi culty significantly , but morbid obesity may require specialist instrumentation and trocars. Patients with a particularly low body mass index and small body habitus may present separate challenges in terms of port placement, particularly when adopting a robotic approach. Severe spinal deformity including kyphosis and scoliosis may present problems in terms of positioning as well as impact on overall recovery if there are associated problems with sputum clearance and mobility . Prophylaxis against thromboembolism V enous stasis induced by the reverse Trendelenburg position during laparoscopic surgery coupled with prolonged duration of operation are risk factors for deep vein thrombosis. Subcuta neous low-molecular-weight heparin and antithromboembolic stockings should be used routinely in addition to pneumatic calf compression during the operation. Patients already taking anticoagulation should have this stopped temporarily or appropriate, be converted to intravenous or subcutaneous heparin, depending on the underlying condition and local thromboprophylaxis protocols. In most cases patients can continue on aspirin when the benefits outweigh the slight increase in bleeding potential. Urinary catheters and nasogastric tubes In the early days of minimal access surgery , routine bladder catheterisation and nasogastric intubation were advised. Most surgeons now omit these in favour of enhanced recovery , which has demonstrated benefits in terms of both length of stay and morbidity outcomes. It remains essential to check that Friedrich Trendelenburg , 1844–1924, Professor of Surgery successively at Rostock (1875–1882), Bonn (1882–1895), Leipzig (1895–1911), Germany . The Tren delenburg position was first described in 1885. particularly before creating pneumoperitoneum for minimal access surgery approaches to the abdomen. Informed consent It is essential that the patient understands the nature of the procedure, the risks involved and, when appropriate, the alternatives that are available. A locally prepared explanatory booklet concerning the minimal access procedure to be under - taken is extremely useful (Chapter 14). The patient should understand that the procedure may be converted to an open operation. Common complications should be mentioned, such as shoulder tip pain and minor surgical emphysema, as well as rare but serious complications, suc h as inadvertent visceral injury from trocar insertion or diathermy . Patients may also have specific questions or requests in terms of the application of minimal access surgery . It is important to be considerate and address these. Some patients remain concerned about the application of technology , particularly robotics, to their care and it is important to ensure they understand and agree with the proposed surgical approach. -

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Figure 10.5 Management of bleeding from a surgical trocar site.

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Most of the trauma of an open procedure is inflicted because the surgeon must have a wound that is large enough to give adequate exposure for safe dissection at a target site. The wound is often the cause of morbidity , including infection, dehiscence, bleeding, herniation and nerve entrapment. Wound pain prolongs recovery time and, by reducing mobility , contributes to an increased incidence of pulmonary atelectasis, chest infection, paralytic ileus and deep venous thrombosis. Mechanical and human retractors cause additional trauma. Body wall retractors can inflict localised damage that may be as painful as the wound itself. In contrast, during laparoscopy , the retraction is provided by the low-pressur e pneumoperitoneum, giving a di ff use force applied gently and evenly over the whole body wall, causing minimal trauma. Exposure of any body cavity to the atmosphere also causes morbidity through cooling and fluid loss by evaporation. The incidence of postsurgical adhesions is reduced by use of mini mally invasive approaches because there is less damage to del icate serosal coverings. In the manual handling of intestinal loops, the surgeon and assistant disturb the peristaltic activity of the gut and provoke adynamic ileus. While minimal access methods were initially established in elective surgery , the advantages have led to increased uptake for a number of emergency surgical procedures, including perf orated viscus repair, such as omental patch repair of a peptic ulcer perforation, lavage of localised perforation of diverticular disease, intrathoracic debridement of empyema and pneumothorax and haemothorax surgery . More recently , some experienced surgeons have chosen to employ minimal access approaches to trauma situations for initial assessment and treatment in stable patients. Advantages of minimal access surgery /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF - /uni25CF /uni25CF

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Patients should be warned about this preoperatively and informed that the pain is referred from the diaphragm and that it is not due to a local problem in the shoulders. It can be at its worst 24 hours after the operation. It usually settles within 2–3 days and is relieved by simple analgesics, such as paracetamol. Shoulder tip pain

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Single-incision minimal access surgery

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- Single-incision minimal access surgery has varied in popularity with both strong advocates and others who are sceptical of any advantages. Single-incision laparoscopic surgery (SILS) involves insertion of all instrumentation through a multiple channel port via a single incision at the umbilicus. The benefits are that the incision, through a natural scar (the umbilicus), is virtually 'scarless' and that fewer port sites potentially reduces pain and lessens the risks of port site bleeding and the potential for port site hernia. SILS requires specially manufactured multichannel ports - and often roticulating instruments. It has most commonly been adopted in gallbladder and hernia surgery , although more in vitro fertilisation. remains debate as to whether the increased procedural di ffi culty , steep learning curve and increased direct costs in terms of devices, instruments and operating time can be o ff set by significant clinical benefit. Uniportal thoracic surgery requires less specialist equip ment; many minor thoracic procedures are commonly per formed using this technique. More complex resectional procedures are less commonly performed, largely because of technical complexity when compared with multiport niques, which are on the whole very well tolerated. Single-incision minimal access surgery
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Many surgical specialties have embraced robot-assisted techniques, including general surgery , cardiothoracic surgery , urology , orthopaedics, ear, nose and throat surgery , gynaecol ogy and paediatric surgery . Specialties that use microsurgical techniques also benefit from this technology . Current robotic systems were designed to o ff er multifunctionality , including multianatomy and specialty capability in both operating thea tre and remote environments. Currently , despite a small number of reports of remote surgical procedures, robotic surgery remains focused on in-house operating. New entrants In 2017, Intuitive Surgical released the da Vinci X, a low-cost entry point in its robotic surgical portfolio that includes features of the Xi while sacrificing some flexibility in terms of multi- quadrant surgery . In the same year, Korean company Meere gained a licence for the use of its surgical robot, the REVO-I, by the local Ministry for Food and Drug Safety . Similar to the da Vinci, this four-arm robot is mounted on a single cart. The surgeon is seated at an open vision cart and, by use of 3D glasses, can achieve three-dimensional high-definition (3D-HD) vision. In March 2019, CMR Surgical received a European CE mark for its novel modular robot, the V ersius (Figure 10.4). This system incorporates individual cart-mounted modular robotic arms that can be configured to fit the procedure and the operating room environment. The design di ff ers from other robotic arms in that it aims to more closely mimic a human ar m, improving freedom of port placement. Its vision cart similarly allows for ergonomic operating with 3D-HD vision, through the use of 3D glasses. Bridging the gap between laparoscopic and robotic surgery ® the Senhance robotic system received its CE mark in 2016. In order to reduce cost and sustain familiarity with conven tional laparoscopy , the system uses independent robotic arms mounted on separate carts that can be placed in accordance with the procedure required. T he system utilises reusable non wristed instruments that can be inserted through standard system also creates familiarity with conventional laparoscopy and facilitates hybrid techniques where this may be beneficial. Surgery is enhanced though a 3D-HD system with the use of 3D glasses and eye-tracking camera control. As the field of robotic surgery continues to expand and innovate, there also remain a number of systems in devel - opment that are not yet approv ed for clinical use. Examples - similar to existing technologies include the Medtronic Hugo Robotic-Assisted Surgery (RAS) system, which was launched in late 2019. This modular system aims to provide a low er cost alternative by means of a more readily upgradeable model that may be used flexibly across surgical specialties and procedures. Moving forward, companies such as V erb Surgical strive to build on the currently dominant master–slave model, incorpo - rating robotic autonomy and machine learning. While this may in time revolutionise robotic surgery , such technologies remain in the early phase of development.

Figure 10.4 The Versius robotic system (courtesy of CMR Surgical).

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Urinary catheter

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The requirement for a urinary catheter depends on the opera - tion. In shorter (<4 hours) minimal access procedures a urinary catheter is not usually required. If a urinary catheter has been placed in the bladder during an operation with likely short stay , it can be removed before the patient reg ains conscious - - ness if the procedure has been uneventful. Postoperatively it is important to check that the patient has been able to pass urine and empty their bladder without di ffi culty . When there is uncertainty point-of-care bladder scanning can assess residual bladder volume.
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