The Physiologic and Anesthetic Considerations in Elderly Patients Undergoing Robotic Renal Surgery

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A number of patients are diagnosed with renal malignancies incidentally worldwide. Once a diagnosis of a renal malignancy is established, after a careful evaluation, patients can be offered a robotic nephrectomy or partial nephrectomy. We present a review of the physiologic and anesthetic considerations in elderly patients who are being considered for robotic renal surgery.

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KEY WORDS

Robotic partial nephrectomy • Robotic radical nephrectomy • Physiologic considerations • Anesthetic considerations

From the mid-1970s through the mid-1990s, the incidence of renal cell cancer (RCC) has risen by approximately 3% per annum in the United States[1] and 2.5% per annum in northern England.[2] The main reason for an increase in the incidence of RCC is the increased detection of early and pre-symptomatic tumors by routine radiologic imaging.[2] Urologists are now seeing more patients with RCC at early stages (T1) and offering these patients a robotic partial nephrectomy (RPN) or robotic radical nephrectomy (RRN) if the surgical expertise is available.[3] A minimally invasive partial nephrectomy for small renal masses has been reported to show excellent functional and oncologic outcomes, with 5- to 10-year cancer-specific survival rates of 95% to 100%.[4]

Many of the patients with newly diagnosed RCC are of advanced age and/or have some major

comorbidity that often results in their poor performance status. It is envisaged that with an increase in life expectancy, urologists and urologic oncologists will see an increase in new referrals of RCC.[5]

With the introduction of robotic renal surgery in the United Kingdom, it is likely that more patients will undergo an RRN/RPN over the next decade. Current literature supports the use of RPN in patients versus laparoscopic partial nephrectomy (LPN) due to a reduction in the warm ischemia time (WIT).[6] This factor is of crucial importance in patients with a solitary kidney or patients with renal impairment undergoing a partial nephrectomy. The WIT reduces with RPN when compared with LPN.[7]

We present a review of the important physiologic and anesthetic considerations in patients being considered for an RPN or RRN.

Background

As patients live longer and more renal malignancies are diagnosed incidentally on radiologic imaging, it is anticipated that more elderly patients will be offered minimally invasive surgery, including robotic RPN or RRN.[4-6] The balance of risk versus benefit for RPN or RRN is often difficult in this group; undoubtedly, there is considerable risk attached to surgery. Denying surgery on the basis of comorbidities and advanced age can result in disease progression and progressive symptoms from the renal pathology identified, including hematuria, chronic anemia, pain, especially in elderly patients diagnosed with RCC.[8,9]

Many of the complications seen in patients undergoing either an RPN or RRN are explained by examining the physiologic changes associated with robotic surgery. Patients undergoing an RPN or RRN are rarely without additional comorbidities and the profound physiological changes that can occur with robotic surgery require careful modulation to prevent adverse events.[6,10,11]

The major advantage of performing minimally invasive robotic surgery lies within the intraoperative period, during which blood loss is less in comparison with open radical partial nephrectomies.[12-14] However, additional advantages lie within the postoperative period, during which recovery is swifter and a lower level of postoperative pain leads to several benefits, including a reduction in the amount of analgesic medication required.

Patients undergoing an RPN or RRN are rarely without additional comorbidities and the profound physiological changes that can occur with robotic surgery require careful modulation to prevent adverse events.

The main disadvantage of robotic renal surgery is physiologic disturbance, mainly due to the pneumoperitoneum and patient positioning. It is important to consider these disturbances when preoperatively assessing patients to specifically look for pathologies that will increase risk. Robotic surgery requires insufflation of the peritoneum with carbon dioxide to a pressure of 10 to 15 mm Hg, maintained by a constant flow of gas. The increase in the intra-abdominal pressure (IAP) also impacts on any and all collapsible structures within the cavity, causing significant impact on the various body systems. Even seemingly healthy patients preoperatively will exhibit many of the responses detailed next when physiologically stressed. Although they may have sufficient health to prevent any limitations on a daily basis, the stress of surgery will reveal decreased reserves.

Cardiovascular System

Physiological Considerations

Venous return (VR) to the heart is reduced by compression of the inferior vena cava leading to a reduction in stroke volume. Cardiac output (CO) is a function of heart rate and stroke volume; in elderly patients, the ability to compensate for the reduced VR may be particularly compromised by an already failing heart, as per the Starling curve, and the commonly used rate control drugs (eg, β-blockers) prevent compensatory heart rate increase. The increased IAP and emission of stress hormones such as catecholamines also directly increase the systemic vascular resistance (SVR) and therefore help maintain the blood pressure (BP), as BP = CO × SVR. There is a loss of response to catecholamines in the octogenarian due to receptor downregulation, and the additional stress placed on the heart by reduced preload (VR), increased afterload (SVR), and tachycardia increases the risk of myocardial ischemia. In an elderly, often hypertrophied and stiff heart, the stretch from VR is insufficient for cardiac muscle work; there is too much pressure to pump out against and too little time in diastole, from the high heart rate, to allow relaxation and filling of the ventricle and sufficient perfusion of already constricted coronary arteries. The pneumoperitoneum also carries a risk of provoking an arrhythmia, particularly a bradycardia, associated with the stretch of the peritoneum on insufflation.

These effects can be profound and catastrophic in those with severe heart disease; therefore, patients should be screened for both

coronary artery disease (CAD) and heart failure very carefully at preoperative assessment. Perioperatively, octogenarians will benefit from an increase in cardiac monitoring to facilitate manipulation of their physiology; routinely in our institution, this would involve the use of arterial pressure monitoring and CO monitoring with esophageal Doppler ultrasound. The aforementioned cardiac limitations and the impaired autonomic homeostasis seen in the elderly lead to an increased likelihood of postoperative hypotension and consequent risk to renal and other organ perfusion.

CAD

Cardiovascular testing is only indicated if it is likely to alter perioperative management.[15] The 2007 American Heart Association/American College of Cardiology guidelines suggest noninvasive testing is only appropriate in those with functional limitation and ≥ 1 cardiac disease risk factor.[15] Only those who cannot perform exercise testing should be referred for dynamic stress testing with myocardial perfusion scanning or stress echocardiogram; only those with contraindications to stress testing or positive results should be referred for coronary angiography. Coronary angiography carries a 2% risk of major morbidity and should not be used as a first step for preoperative evaluation. The value of preoperative coronary revascularization, should a significant stenosis be found, is unclear and unproven. The small studies done so far do not find any benefit to mortality in those who have had revascularization preoperatively.[15]

Optimization of cardiac disease must include attention to medications. Statins not only reduce cholesterol, but there is also increasing evidence that they stabilize coronary artery plaques, which reduces rupture rate and consequent myocardial infarction.

β-Blockers can be both useful and detrimental in the elderly patient undergoing RNN, and their use is controversial.[16] A degree of heart rate response is required to compensate for reduction in stroke volume; however, in the heart with compromised coronary circulation, even a small degree of tachycardia can induce ischemia and infarction. Generally, we consider introduction of β-blockade in the elderly patient if cardiopulmonary exercise testing (CPET) showed obvious ischemia due to tachycardia causing reduction in anaerobic threshold. Referral to cardiology services is considered in the patient with unstable or worsening angina, or undiagnosed CAD.

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Valve Disease

The effect of moderate to severe aortic stenosis, which is found more commonly in the older population and in up to 8% of those aged 85 to 86 years,[17] can be devastating. This is a fixed-output state and the already hypertrophied ventricle cannot respond to additional demand and is very prone to ischemia. This is perhaps the most concerning of the valve lesions from the perioperative perspective; however, severe valve disease elsewhere must not be discounted. A history of known valve disease or the presence of a murmur with either exercise limitation or electrocardiography (ECG) changes warrants ECG evaluation. Delaying cancer surgery to allow valve replacement surgery may not be practical and is always a balance of risk; however, full assessment of the valve disease allows proper stratification of risk and assists choice of postoperative care level requirement.

Heart Failure

Heart failure is common in the elderly, with a prevalence of approximately 8% in those aged 75 to 86 years.[18] Although CAD is an important risk factor for perioperative mortality and morbidity, heart failure carries a two- to fourfold operative mortality compared with a patient with CAD.[19] There is clearly a spectrum, with patients in New York Heart Association (NYHA) class 4 (symptoms at rest) carrying an extremely high mortality risk. In patients with dyspnea, clinical signs or markedly reduced mobility, screening for heart failure with B-type natriuretic peptide is useful where available, and alternatively, the use of CPET or dynamic testing to demonstrate function or echocardiography to demonstrate resting ejection fraction and check for diastolic dysfunction. Robotic renal surgery can significantly impact on the degree of heart failure due to poor rate control and loss of the atrial assistance with ventricular filling; this is particularly detrimental in the presence of aortic stenosis. The preoperative diagnosis and institution of heart failure treatment is essential with planning for upper level care in the postoperative period. New treatments, such as the inotrope levosimendan, are showing promise but are not yet in routine use.[20]

Respiratory System

The pneumoperitoneum can cause pneumothorax, pneumomediastinum, and subcutaneous

emphysema, but these effects are rare. The pneumoperitoneum causes significant respiratory effects by shifting the diaphragm and thereby reducing functional residual capacity. If this drops below the closing volume of the lungs it will lead to airway collapse, atelectasis, and ventilation/perfusion (V/Q) mismatch. In the elderly, closing volume is increased, making this more likely to occur; they also have loss of elasticity of the airways and increased chest wall stiffness that potentiates the increase in airway resistance and reduced compliance caused by the pneumoperitoneum, and contributes to necessarily high ventilatory pressures and an increased risk of barotrauma. The absorption of intra-abdominal carbon dioxide adds to the risk of hypercapnia in all patients, but the effect is more pronounced and difficult to manage in the elderly.[14] The impaired gas exchange seen with aging contributes significantly to an overall increased risk of intraoperative hypoxia and hypercapnia, even before the increased prevalence of chronic lung disease is considered. The lateral position of the patient for RRN can also significantly affect the patient with asymmetric lung disease; if the dependent well-perfused lung has particular airway disease, the V/Q mismatching will be even more pronounced.

Airway collapse takes longer to resolve in elderly patients, the respiratory reserve is less, with a lower baseline partial pressure of oxygen in the blood (PaO_2), and they also have a tendency to poor coughing force, leading to an increased risk of postoperative hypoxia, respiratory failure, and chest infections. The elderly patient has a reduced response to hypercapnia and hypoxia and may not exhibit the same evidence of respiratory distress as a younger patient at the same level of respiratory failure. Actively seeking patients with lung disease preoperatively and optimizing their condition is essential, as is early recognition of postoperative dysfunction.

Chest Disease

Chronic obstructive pulmonary disease (COPD) is more common in the elderly and the extent of the deficit must be examined. Those patients with a forced expiratory volume in 1 second (FEV_1) $< 50\%$ predicted are at significantly increased risk, as are those with raised $PaCO_2$ on blood gases or supplemental oxygen requirements. Patients with consequent pulmonary hypertension or right heart dysfunction are at extremely high risk.

Other strong predictors of postoperative pulmonary complications are age > 70 years, duration of surgery > 2.5 hours, COPD or poorly controlled asthma, obesity, presence of a nasogastric tube, and smoking.[21] A history of obstructive sleep apnea symptoms is actively sought, as there will be an increased likelihood of postoperative cardiac events. Preoperative testing, therefore, screens for a history of dyspnea and includes basic pulmonary function tests. These must be adjusted for age: an 80-year-old woman, 160 cm tall, has a predicted FEV_1 of 1.86, almost half that of that found in a woman at age 40 ($FEV_1 = 2.86$). Oxygen saturations must be checked preoperatively and consideration of arterial blood gas sampling to look for respiratory failure. Smoking should be actively discouraged and assistance offered. Lung disease treatment is optimized and those with severe lung disease may be referred for preoperative review by a chest physician.

Renal and Fluid Management

Renal blood flow reduces in the elderly and glomelular filtration rate (GFR) drops by approximately 1 mL/min per year. Reduced skeletal muscle mass leads to lower levels of serum creatinine. An estimate of GFR (eGFR) is therefore essential both pre- and postoperatively to evaluate the changing renal function; for example, a creatinine of 110 μmol/L in an 85-year-old woman corresponds to an eGFR of 44 mL/min/1.73 m^2 and stage 3 chronic kidney disease (eGFR calculated by the abbreviated Modification of Diet in Renal Disease equation: $186 \times [\text{creatinine}/88.4]^{-1.154} \times [\text{age}]^{-0.203} \times [0.742 \text{ if female}] \times [1.210 \text{ if Africo-Caribbean}]$).

Patients are disadvantaged from the onset as they are usually dehydrated on arrival to the operating room due to preparation for surgery. Intraoperatively, the effects on renal physiology can be divided into direct and indirect effects. The raised IAP associated with robotic surgery causes an increase in renal vascular resistance while causing a direct compression on the renal parenchyma and renal vein. A swine model showed a drop in renal cortical blood flow as much as 60%.[22] Combined with the release of vasoconstrictors from baroreceptors due to reduced CO; GFR is reduced. This is accompanied by a rise in serum creatinine, as demonstrated by Cho and colleagues.[23] The autoregulation mechanism in the renal system compensates by increased release of renin and therefore aldosterone, whereas antidiuretic hormone is released from the pituitary due to reduce plasma volume. All these lead to the retention of salt and water and patients become oliguric. Ahn and associates showed that renal dysfunction recovers postoperatively by increase of creatinine clearance, which continues for up to 7 days after surgery.[24] However, in the elderly where there is little renal reserve, this compensation might not be effective.

In addition to the loss of any functioning renal tissue from nephrectomy, it is not surprising that these patients struggle with renal function, drug excretion, and fluid balance postoperatively. Preoperative screening for renal dysfunction and the frequently asymptomatic urinary tract infections of the elderly is vital. Some studies have tried to treat intraoperative renal dysfunction with prophylactic medications. Cho and colleagues showed a reduction in transient renal dysfunction when the calcium channel blocker nifidipine (0.5 μg/kg/min) was used intraoperatively.[23] This is due to vasodilatation of the afferent arterioles, although, in another study, Pérez and associates found dopamine to be effective in reducing renal dysfunction.[25] More research is needed before these drugs can be implemented clinically, but they might prove to be useful for nephrectomies in the elderly who already have impaired renal function.

If RPN is considered to preserve as much renal function as possible then the WIT needs to be considered. Recent studies have shown that an ischemic time > 40 min could lead to pronounced parenchymal thickness atrophy and a decrease in residual functional capacity.[26] Using renal scintigraphy to compare renal function pre- and postoperatively, Kobayashi and associates showed that risk factors for dysfunction include age > 70 years and reclamping of the renal artery.[27] Some studies have demonstrated a benefit in using slush ice to achieve renal cooling, thereby reducing parenchymal damage. Studies have shown that renal hypothermia offers some renal protection particularly when the ischemic time is prolonged.[28] Indeed, a multicenter analysis by Kaczmarek and colleagues showed that off-clamp RPN has a less damaging effect on postoperative renal function compared with clamping.[29] However, more blood loss is expected and a level of expertise is needed for this technique.

Fluid management has long been an area for improvement in the elderly, as highlighted by the 1999 National Confidential Enquiry into Peri-operative Deaths (NCEPOD) report.[30] The changes seen in the elderly patients undergoing RPN or RRN are both renal and cardiovascular. These functions must be borne in mind when fluid-prescribing is contemplated; the guidance of senior, experienced staff should not be underestimated here. Strict fluid balance monitoring is essential with regular checks to ensure urine output is reaching 0.5 mL/kg/h. The intravenous (IV) fluid prescription must aim to achieve normality of the serum electrolytes. In the smaller, thin, elderly patient, it is often useful to consider rate of IV therapy (IVT) using the pediatric 4,2,1 rule as a guide: so a 45-kg patient would be given 4 mL/kg/h for the first 10 kg (40 mL), 2 mL/kg/h for the next 10 kg (20 mL), and 1 mL/kg/h for the rest (25 mL); overall 85 mL/h as maintenance IVT, plus any losses such as from fever, diarrhea, or bleeding. Elderly patients may take in little food and liquid, even once off IVT, and maintaining a strict fluid balance measurement is equally important at this stage. Early recognition of renal dysfunction with monitoring and daily checks of urea and electrolyte function should highlight those elderly patients in difficulty and direct the need for invasive monitoring and increased level of care.

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Neurologic System

This is a very important consideration in elderly patients undergoing an RPN or RRN. As we age, there is physiologic loss of gray and white matter and neuronal loss that leads to the impaired processing of information. Increased IAP at laparoscopy leads to an increase in intracranial pressure and a possible reduction in cerebral perfusion pressure, particularly if systemic BP is compromised. This increases the tendency for ischemic brain injury and stroke. Common in the elderly is the development of delirium and postoperative cognitive dysfunction (POCD); delirium is a transient disturbance, whereas POCD is a more persistent change in cognition that can be demonstrated on neurologic testing. Delirium is common in elderly hospitalized patients and its duration is often short.[31] Visual hallucinations, anxiety, and distress are all seen, particularly at night, often caused by drugs, infection, electrolyte disturbances, and alcohol withdrawal. Dementia covers a group of organic brain disorders with irreversible pathology and is a risk factor for postoperative delirium.

POCD is found in 25% of patients over age 60 years at 1 week postoperatively and in 10% at 3 months,[32] although the cause is unclear. Elderly people are more likely to have early POCD, and early deterioration increases the likelihood of

long-term POCD.[33] Screening for postoperative change in cognition, for example, using the Mini Mental State Examination,[34] is essential as deterioration may be associated with confusion and reduced compliance with nutrition, mobilization, physiotherapy, and an increased hospital stay.

Skin and Tissues

Elderly patients are more prone to reduced muscle bulk, ligament laxity, arthritis, osteoporosis, and skin atrophy with loss of collagen. They are therefore more likely to bruise, develop pressure sores, and have difficulty in healing. The poor preoperative nutrition common in the elderly can contribute to this. Special care and attention to positioning and pressure areas must be given intra- and postoperatively. Arthritis and fixed deformities may make positioning for RPN particularly difficult, and can impact on the ability to intubate the trachea due to reduced neck mobility. Venous access can be difficult due to the fragile nature of elderly veins and adhesive tapes can easily rip the skin unless due care is used. Specialized dressings may be needed in some patients.

Increased sensitivity to many drugs is seen and caution must be used; for many sedative and opiate drugs, starting with half the standard dose may be appropriate. Whenever possible, drugs that are short acting and easily eliminated from the body should be considered.

Drug Handling

Elderly patients undergoing an RRN or RPN have a variable response to drugs due to a spectrum of changes with increased body fat, reduced total body water and muscle mass, and the reduction in the ability to process drugs due to renal and hepatic impairment.[35] Increased sensitivity to many drugs is seen and caution must be used; for many sedative and opiate drugs, starting with half the standard dose may be appropriate. Whenever possible, drugs that are short acting and easily eliminated from the body should be considered. Absorption of oral drugs is dependent on a gastrointestinal tract that is more prone to stasis and must be considered when choosing the route of administration. Morphine is hydrophilic and the decreased total body water content in the elderly means that the volume in which the drug is distributed is smaller and the pharmacologic effect greater. Build-up of active metabolites is more likely if any degree of renal impairment is present; morphine-6-glucuronide is a major metabolite, excreted by the kidney, that is twice as potent as morphine and has a longer half-life. A good alternative to a morphine patient-controlled anesthesia (PCA) in these patients is to use a fentanyl PCA, which has a much-reduced duration of action and is eliminated by the liver, making it safer to use in patients with renal dysfunction.

Remifentanil is an ultra–short-acting opiate given by infusion that is broken down by tissue and plasma esterases and, therefore, renal and liver dysfunction have little effect. Remifentanil is particularly useful in the octogenarian having robotic surgery to blunt any hypertensive responses intraoperatively; however, caution must be used with dosing, which again should be reduced due to a reduction in volume of distribution of about 20% in the elderly. Paracetamol is a good drug to use regularly in the elderly, but caution not to exceed a dose of 20 mg/kg four times daily should be exercised for the smaller, thinner patient.

Nonsteroidal anti-inflammatory drugs (NSAIDs) are not suitable for most septuagenarians undergoing nephrectomy; they carry too high a side-effect profile of renal dysfunction and gastrointestinal bleeding in the elderly. NCEPOD 1999 noted the need to avoid NSAIDs in elderly patients with renal dysfunction and in those on concurrent angiotensin-converting enzyme inhibitors. Of the anesthetic drugs, propofol is highly protein-bound and even moderately reduced albumin, as often seen in the elderly, will increase the amount of free drug and, hence, action. The slower circulation in the elderly leads to a slow onset of effect and propofol, as with other induction agents, must be given slowly to prevent overdosing and consequent hypotension. Inhalational agents have a lower minimum alveolar concentration in the elderly. Neuromuscular blockade is necessary for intubation, although does not often need maintaining if using remifentanil. Muscle relaxants are very water soluble so their effects are greater, again due to the volume of distribution. Those eliminated by the liver and kidneys should be avoided; instead, those eliminated by other means should be considered, such as atracurium and cisatracurium, which are eliminated mainly by Hoffman degradation and ester hydrolysis. β-Agonists and antagonists are less efficacious in the elderly due to their reduced catecholamine-receptor function; therefore, intraoperative hypotension may be better managed by a pure α-agonist such as phenylephrine.

Temperature

Awareness of the importance of intraoperative normothermia has been heightened recently

following the publication of the National Institute for Clinical Excellence guidelines,[36] and its benefits are well known. This is particularly important in the elderly because reduced metabolic and muscular reserve may make it difficult to get back to normal body temperature levels once hypothermia ensues. Simple measures such as ensuring sufficient blankets pre- and postoperatively are vital and active warming intraoperatively, with core temperature monitoring, must be considered during robotic nephrectomy, during which there is reduced access for warming blankets and possible prolonged procedure time.

Other Systems

In the postoperative period following an RRN or RPN, patients may have a reduced gastrointestinal motility and are more prone to reflux and constipation. Feeding may be more difficult to re-establish and if consciousness level is reduced, aspiration is more likely to occur. Gastritis and bleeding are also more likely to occur and the elderly patient who is not taking an enteral diet should be considered for prophylactic acid-reducing medications. Reduced T-cell, B-cell, and macrophage function leads to a reduced immune response to infection in which lack of high temperature and raised white cells can be misleading. In this group, it is important to be alert for postoperative infections, particularly the common chest infection, which may present with little more than mild postoperative confusion. Septuagenarians have reduced sensory perception including sight, hearing, and balance. This makes communication difficult and contributes to prolonged rehabilitation. It is essential to take the extra time necessary with this special group to ensure all their needs are met.

Lateral Decubitus Position

Patients are positioned in the lateral decubitus position for an RRN or RPN. The kidney rest lateral decubitus position requires a hip flexion of 30° vertically to increase lateral flexion and to access the upper kidney. Studies have shown that this position can lead to a significant reduction in CO and mean arterial pressure compared with the supine or lateral positions.[37] One mechanism could be reduced VR due to compression of great vessels in the abdomen because of the 30° flexion. Also, the heart is at a hydrostatic level above the lower extremities. Drop in VR reduces preload and therefore leads to a decrease in cardiac output. Another mechanism is the increased SVR index in this position, which increases afterload and therefore decreases stroke volume. Baroreflex is also dampened because of anesthesia and therefore there is lack of reflex tachycardia to compensate for drop in SV and CO.

Respiratory physiology is also affected in this position. This is largely due to V/Q mismatch. The nondependent lung would preferentially receive better ventilation than the dependent lung but perfusion has an inverse relationship. Therefore, a greater proportion of blood flow is going to be the less-ventilated part of the lung, increasing physiologic dead space. In addition, there is further splinting of the diaphragm as abdominal content is not pushed away from the thorax; the dependent hemidiaphragm will be disproportionally pushed into the thorax. Overall, there is reduced tricuspid valve and therefore mechanical ventilation and higher pressure would be needed for invasive intermittent positive ventilation as compared with the supine position. This rise in intrathoracic pressure further reduces VR and therefore CO. Patients should therefore be optimized preoperatively and then be closely monitored intraoperatively using invasive techniques.

Steep Trendelenburg Position

The steep Trendelenburg position (STP) is not normally adopted in patients undergoing robotic renal surgery. However, patients undergoing a robotic nephroureterectomy are placed in STP to facilitate mobilization of the distal ureter. It has been reported that patients placed in this position have a significant increase in SV, CO, and cardiac index after induction, after pneumoperitoneum, and immediately after the 45° STP. This fall in hemodynamics might be further compounded with carbon dioxide pneumoperitoneum, as it is known to cause increase in SVR and afterload, thereby reducing the stroke volume.[38]

In patients being placed in the STP, there is a risk of developing facial, pharyngeal, and laryngeal edema. The anesthetist monitoring the patient during this procedure must monitor the amount of IV fluid being given to the patient, as a reduction in venous outflow from the patient's head caused by pneumoperitoneum, when either is combined with prolonged STP, may cause an acute development of laryngeal edema. Most anesthetists restrict the amount of fluid being given to reduce this complication.[39]

The STP is associated with the risk of developing increased intraocular pressure. This has been reported in patients undergoing robotic prostatectomy and cystectomy.[40] There have been no reports of ocular complications to date in patients undergoing an RRN or RPN.

The specific ophthalmic complications of the STP include corneal abrasions and ischemic optic

neuropathy. The etiology of the ophthalmic complications is related to an elevation in the venous pressure in the head-down position, which causes the accumulation from capillary leak, decreased venous outflow, and decreased perfusion of the optic nerve.[41]

Often, patients undergoing an RRN or RPN may present with a range of diseases and general debilitation. It can be difficult to assess which of their diseases contributes most to their limitations and risk.

In patients with ocular complications postoperatively, there is a strong link between intraoperative blood loss and the onset of postoperative complications.[42]

Preoperative Evaluation and Risk

Often, patients undergoing an RRN or RPN may present with a range of diseases and general debilitation. It can be difficult to assess which of their diseases contributes most to their limitations and risk. Preoperative testing must begin with a thorough history, usually obtained in our institution by a trained preoperative assessment nurse. Routine investigations for an RRN/RPN in any age group includes calculation of metabolic equivalents (METs) score, standard blood sampling, including eGFR, midstream urine testing with dipstick, an ECG, and pulmonary function tests. The majority of these patients will, in addition, have had a preoperative assessment by an experienced anesthetist sufficiently prior to surgery to institute testing and optimization. Functional capacity is far and away the most useful check, whether a subjective, METs score adjusted for age, or our current gold standard of CPET, which provides a variety of indicators including an estimate of anaerobic threshold, stroke volume response to exercise, and allows strong prediction of mortality and need for postoperative critical care in the elderly.[43]

The importance of additional preoperative testing has been alluded to in each system discussed. It is important to note that there is no single test or risk score that will give a precise answer for a specific patient; most scoring systems look at only one system and give the risk for that system. The most commonly used current cardiovascular risk prediction assessment is the Revised Lee Cardiac Risk Index.[15] This uses six predictors of cardiac complications: high-risk surgery, ischemic heart disease, congestive heart failure, cerebrovascular disease, insulin-dependent type 2 diabetes, and renal failure. The presence of 0, 1, 2, or 3+ predictors corresponds to an estimated major cardiac complication rate of 0.4%, 0.9%, 7%, and 11%, respectively. This score

MAIN POINTS

- As patients live longer and more renal malignancies are diagnosed, it is expected that more elderly patients will be offered minimally invasive surgery including robotic partial nephrectomy (RPN) or robotic radical nephrectomy (RRN). The balance of risk versus benefit for RPN or RRN is often difficult in this group, and there is considerable risk attached to surgery.
- The major advantage of minimally invasive robotic surgery lies within the intraoperative period where blood loss is less in comparison with open RPNs. The main disadvantage is physiological disturbance, mainly due to the pneumoperitoneum and patient positioning.
- Both coronary artery disease (CAD) and heart failure must be screened very carefully at preoperative assessment. Perioperatively, octogenarians will benefit from an increase in cardiac monitoring to facilitate manipulation of their physiology. Although CAD is an important risk factor for perioperative mortality and morbidity, heart failure carries a two- to four-fold operative mortality compared with a patient with CAD.
- Strong predictors of postoperative pulmonary complications include age $>$ 70 years, duration of surgery $>$ 2.5 hours, chronic obstructive pulmonary disease or poorly controlled asthma, obesity, presence of a nasogastric tube, and smoking. Smoking should be actively discouraged and assistance offered.
- Preoperative testing must begin with a thorough history, usually obtained by a trained preoperative assessment nurse. Routine investigations for an RRN/RPN in any age group includes calculation of metabolic equivalents score, standard blood sampling, including eGFR, midstream urine testing with dipstick, an ECG, and pulmonary function tests.

was validated by Boersma and colleagues in 2005[44] and found to be improvable by incorporating age and surgical type as factors, with an odds ratio of 20 for cardiovascular mortality risk in septuagenarians. Specific diseases should be actively screened for this group of patients including CAD, valve disease, heart failure, and COPD. Other diseases such as diabetes should be well controlled and stable.

Conclusions

It is important to understand the physiologic and anesthetic considerations in patients undergoing robotic renal surgery. When a patient is being considered for this surgery, it is imperative to have a detailed discussion among the surgeon, anesthetist, patient, and where appropriate, an intensivist to optimize a satisfactory postoperative outcome. ■

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