ANAESTHESIA FOR TOTAL KNEE REPLACEMENT
ANAESTHESIA TUTORIAL OF THE WEEK 76

3RD DECEMBER 2007

Dr Helen Bromhead, Locum Consultant Anaesthetist
Royal Hampshire County Hospital UK
e mail: hjbromhead@hotmail.com

Self assessment
Before reading this tutorial please attempt the following questions.

1. With regard to knee replacement surgery:
   (a) Most patients have degenerative knee disease
   (b) Long-term results of TKR are comparable to total hip replacement
   (c) Unicompartmental surgery is relatively more painful
   (d) Bilateral surgery is recommended for most patients with bilateral disease

2. Options for anaesthetic technique include the following:
   (a) General anaesthesia with femoral and sciatic nerve blocks
   (b) Femoral and sciatic nerve blocks alone
   (c) Combined spinal and epidural anaesthesia
   (d) Spinal anaesthesia alone

3. Concerning femoral and sciatic nerve blocks for postoperative analgesia:
   (a) Single shot techniques provide good analgesia for 48 hours
   (b) Most patients require a urinary catheter
   (c) They allow the patient to be mobile in bed
   (d) Femoral nerve block alone is a recommended technique

4. With regard to use of a tourniquet:
   (a) Antibiotic prophylaxis should be given 15 minutes before tourniquet inflation for full penetration into the tissues
   (b) Tourniquet inflation may precipitate heart failure
   (c) Tourniquet pain commonly occurs after 30 minutes causing increased heart rate and blood pressure
   (d) Tourniquet pain is prevented by adequate regional anaesthesia

5. Hypotension after deflation of the tourniquet may be due to:
   (a) Release of acidic products of metabolism from the leg
   (b) The affected limb filling with blood
   (c) Blood loss
   (d) Cement implantation syndrome

6. Concerning the post operative recovery period
   (a) Pain is usually mild
   (b) Blood transfusion is required infrequently
   (c) Epidural analgesia for the first 24 hours offers significant advantages
   (d) Clinical deep venous thrombosis occurs in 10% of patients if prophylaxis is not used

Key points

- Post operative pain can be severe and is a major determinant of anaesthetic technique
- Be aware of tourniquet problems
- Prevention of venous thrombo-embolism is of key importance

Introduction

Total knee replacement (TKR) is a common orthopaedic operation generally performed in elderly patients. It has a high success rate with long term results comparable to those of total hip replacement.

Surgery

The knee joint is a hinge joint between the lower end of the femur and the upper end of the tibia. The ends of the bones are covered by a layer of cartilage, which allows smooth movement. When the cartilage is damaged by arthritis, joints become stiff and painful. Most patients have degenerative knee disease, commonly osteoarthritis (OA). Other conditions requiring knee replacement include rheumatoid arthritis, knee injury or knee deformity, haemophilia and gout.

Joint replacement is performed to relieve pain and improve mobility. Surgery usually takes 60-90 minutes and involves the following stages:

1. The damaged ends of the tibia and femur are cut away
2. The end of the femur is replaced by a single curved piece of steel alloy
3. The end of the tibia is replaced by a flat plate of steel alloy or titanium with plastic spacer
4. The prostheses are attached using cement or a special press-fit technique.

Unicompartmental knee replacement (hemiarthroplasty, Oxford knee replacement) is sometimes performed in patients with single compartment arthritic changes. It takes less time than a total knee replacement and is considerably less painful postoperatively.

Preoperative assessment

Patients are usually elderly and commonly have associated problems such as hypertension, ischaemic heart disease, chronic obstructive pulmonary disease and renal impairment. They may also have other problems relating to the underlying orthopaedic condition, particularly in rheumatoid arthritis. Therefore careful preoperative evaluation is essential to identify risk factors and ensure that the patient is as fit as possible for surgery.

Cardiopulmonary reserve is often difficult to assess as exercise tolerance is usually limited by knee disease in these patients. If untreated ischaemic heart disease, valvular dysfunction or arrythmias are detected then further investigation may be required to start treatment prior to elective knee surgery. Echocardiography can be used to assess left ventricular function and valvular abnormalities. A resting ECG may show silent ischaemia or previous MI, but is more often normal in patients with ischaemic heart disease. However these tests only provide information about the cardiovascular

system in the resting state. Tests of dynamic function such as cardiopulmonary exercise testing (which can be performed using an arm ergometer) or pharmacological stress tests provide greater information but are not readily available.

Renal function may be impaired due to age, hypertension or chronic use of non-steroidal anti-inflammatory drugs.

Musculoskeletal - other joint involvement is common. This may have implications for positioning for regional anaesthesia and surgery. Obesity may be present as a cause or result of degenerative joint disease. In RA the cervical spine and temporomandibular joint (TMJ) may be involved. Atlantoaxial subluxation occurs in approximately 25% of patients with severe RA. Excessive movement during anaesthesia can result in cervical cord compression. Unless certain that the cervical spine is stable treat as unstable neck – this may involve neck stabilization during intubation, or awake intubation. TMJ involvement may result in restricted mouth opening. Regional anaesthesia may be the best option in these patients.

Drugs - Patients may be taking drugs which have implications for regional anaesthesia such as warfarin, aspirin or clopidogrel. Many elderly patients are on cardiovascular treatments such as beta blockers and ACE inhibitors. Beta blockers should be continued perioperatively; ACE inhibitors may be stopped particularly if a regional technique is selected. Enquire about antibiotic allergies.

General – Consider other important factors which may influence choice of anaesthesia – patient weight and shape of back, whether the patient will tolerate being awake and patient choice.

Investigations – all patients should have:

(1) Full blood count
(2) Urea, creatinine and electrolytes
(3) ECG if aged over 60 or any other clinical indication
(4) Group and save

Other tests as indicated – e.g. coagulation, and chest X-ray

Choice of anaesthetic

Surgery can be performed under general, spinal or epidural anaesthesia, and femoral and sciatic nerve blocks may be used to provide analgesia. Postoperative pain can be severe and is a major determinant of anaesthetic technique. Early mobilisation may be planned using a passive movement machine, which flexes the knee to a prescribed degree and is painful without nerve blockade. Other factors to consider include:

1. Side effects of general anaesthesia and regional techniques
2. Requirement for urinary catheterisation
3. Blood loss
4. Risk of deep venous thrombosis
5. Patient preference – asleep versus awake
6. Complexity and time taken
7. Ability to actively mobilise from 24-48 hours
8. Cost

The optimum technique provides high patient satisfaction, minimal risk, excellent postoperative analgesia with minimum side effects, and allows early mobilisation.

The following anaesthetic and analgesic techniques are commonly used:

1. Femoral and sciatic nerve blocks – combined with spinal or general anaesthesia
2. Femoral nerve block alone combined with spinal or general anaesthesia
3. Epidural analgesia - combined with spinal or general anaesthesia
4. Spinal anaesthesia alone
5. General anaesthesia (GA) alone

Femoral (3 in 1) and sciatic nerve blocks have become popular and provide good analgesia in the first 12-24 hrs. They avoid the need for a urinary catheter in most patients and allow mobility in bed. They need 30 minutes to become effective and do not provide surgical anaesthesia. Some anaesthetists place catheters for continuous nerve blockade, but this requires experience, skill and regular practice. The advantage of prolonged analgesia may be outweighed by delayed active mobilisation.

Femoral (3 in 1) nerve block alone is quicker and simpler to perform. There is evidence to suggest that the analgesia provided is adequate if supplemented by systemic analgesics, and that the additional benefits of providing sciatic nerve block may be outweighed by increased risk of complications.

Epidural analgesia provides excellent pain relief which can be extended postoperatively. However adequate anaesthetic input and training of nursing staff is essential to deliver high quality postoperative epidural analgesia. There is a higher incidence of complications with epidural analgesia compared to peripheral nerve blocks. Urinary catheterisation is required and mobilisation may be delayed. Patients may dislike the sensory and motor disturbance affecting both legs. Epidural anaesthesia does not provide any significant advantages after the first 6 hours.

Spinal anaesthesia is ideally suited for knee replacement for patients who do not mind being awake and have no contraindications. There is a reduced risk of venous thromboembolism and reduced blood loss compared with general anaesthesia. Spinal anaesthesia provides early postoperative analgesia which can be supplemented by use of intrathecal diamorphine (0.25-0.5mg) followed by systemic opioids given intramuscularly or by patient controlled analgesia (PCA). Patients should be advised to start using the PCA as soon as the spinal begins to wear off to ensure that adequate drug loading occurs before pain becomes severe.

Opioid analgesia after general anaesthesia is an option but significant doses of opioid are required, and in some patients pain may be difficult to control.

Ultimately the choice of technique for an individual patient depends on a number of factors including patient choice, local practice and facilities, and the skills of the anaesthetist.

Perioperative

Monitoring – all patients should be monitored with blood pressure (usually non-invasive), ECG and pulse oximetry. Capnography, inspired oxygen, volatile agent analysis and airway pressure monitoring are indicated for general anaesthesia.
IV lines –14-16g cannula.
Temperature – keep patients warm – use forced air warmer if available. Hypothermia may cause poor wound healing, infection, cardiovascular dysfunction and increased blood loss.
Position – the patient is supine for surgery and airway control can be a problem if sedation is used.
A **tourniquet** is commonly used; therefore perioperative blood loss is not a problem until its release.
Antibiotic prophylaxis is required and should be given 5 minutes before tourniquet inflation for full penetration into the tissues.
Tourniquet pain commonly occurs after about 1 hour, causing a raised heart rate and blood pressure. It can occur with regional anaesthesia even with adequate sensory block. Treatment is by deepening anaesthesia or adding opioids, but may not be completely effective until the tourniquet is deflated. Beta blockers, such as labetolol, are occasionally useful.

Spinal anaesthesia

Check for any contraindications to spinal anaesthesia.
Avoid excessive preload before performing spinal as exsanguination of the leg prior to tourniquet inflation can cause up to 800mls of blood to enter the remaining circulation, which may put the patient at risk of heart failure.
Monitor blood pressure closely and use vasoconstrictors as necessary.
For a single shot spinal use 2.5 – 3.0 mls of 0.5% bupivacaine depending on patient size. Consider addition of 0.25 – 0.5mg diamorphine.
Light sedation using increments of midazolam 0.5mg or low dose target controlled infusion of propofol may be used, but be aware that in the supine position airway obstruction commonly occurs. It is advisable to use general anaesthesia with definitive airway control for patients who do not wish to be awake.

General anaesthesia

Spontaneous ventilation with a laryngeal mask airway or ventilation via an emdotracheal tube are appropriate.

Placement of peripheral nerve blocks – awake or asleep?

If peripheral nerve blocks are used, placement prior to induction of anaesthesia has theoretical advantages of early identification of intraneural or intravascular injection, and also gives more time for the blocks to work before the start of surgery. However there is a body of established opinion that peripheral nerve blocks may be conducted in anaesthetised patients assuming that the technique is meticulous.

Postoperative

Postoperative pain may be severe. All patients should receive regular paracetamol and a non-steroidal anti-inflammatory drug (NSAID) unless contraindicated. Parenteral opioid may be administered by PCA or intramuscular injection to supplement peripheral nerve blocks as necessary.
Fluid balance –after release of the tourniquet most blood loss occurs in the recovery area. Careful fluid balance is essential as hypovolaemia is poorly tolerated in elderly patients.
Check haemoglobin 24 hours postoperatively and treat with iron as necessary. Blood transfusion is required only rarely.
Patients usually undertake **passive exercises** in the operated leg within 24 hours which requires good analgesia, and are **mobilised** at 48 hours.
Oxygen therapy for 24 hours is advisable in most patients, continued up to 72 hours in those at high risk of myocardial ischaemia.

Complications

Blood loss
Blood loss may be brisk after deflation of the tourniquet, and if it exceeds 500 mls the surgeon may clamp the drain for a period. The use of reperfusion drainage systems, in which drained blood is transferred back to the patient, is well established. However there is an increase in febrile episodes associated with the use of such systems. Hidden loss in the tissues may equal the visible loss. Aprotonin may be used in severe bleeding.

Tourniquet deflation
After deflation of the tourniquet a short-lived reperfusion event commonly occurs. Acidic products of metabolism are washed out of the limb causing peripheral vasodilatation and reduced cardiac contractility, both of which result in a drop in blood pressure. In addition the limb fills with blood, reducing filling pressures and exacerbating hypotension. End-tidal CO_2 rises by up to 2.5 kPa and a fall in oxygen saturation is often seen. Prevention involves fluid loading before and during tourniquet release. Additional oxygen and vasopressors may be required.

Cement problems
Cement implantation syndrome resulting in hypoxia and hypotension may occur after insertion of the prosthesis. It is less common than in hip replacement where high pressure is used to apply the cement. If a tourniquet is used the effects may be delayed until the tourniquet is deflated and further contribute to the fall in blood pressure that occurs at that time.

Venous thromboembolism
Deep venous thrombosis (DVT) is more common after total knee replacement than hip replacement. DVT can be demonstrated by venography in up to 65% of patients although most of these are distal calf thromboses with low risk of pulmonary embolus. Clinical DVT occurs in 10% of patients without prophylaxis and fatal pulmonary embolism in 0.4% of patients. Strategies to minimise risk include avoiding

dehydration, early mobilisation, regional anaesthesia, intermittent leg-compression devices and graduated compression stockings. There is strong evidence for the effectiveness of low dose heparin, low molecular weight heparin (LMWH), warfarin or the selective factor Xa inhibitor, fondaparinux in reducing DVT, but there is also concern about possible bleeding complications which may put surgical wound, implant or patient at risk. Local policies should be in place, but recent evidence based guidelines advise that all patients should be offered mechanical prophylaxis plus LMWH or fondaparinux.

Bilateral total knee replacement

Bilateral TKR is a major cardiovascular stress and should only be undertaken with extreme care in young, fit, motivated patients. Invasive monitoring should be considered. GA and epidural is probably the most practical anaesthetic technique.

Revision of total knee replacement

The technique and requirements are similar to TKR except that surgery takes longer (at least 2 hours). If surgery is being performed without the use of a tourniquet then 2 units of blood should be available.

Answers to self assessment

1. TTFF 2. TFTT 3. FFTT 4. FTFF 5. TTTT 6. FTFT

References

White L. Orthopaedic and trauma surgery. Lee's Synopsis of Anaesthesia 13th edition. Davies NJH, Cashman JN Butterworth Heinemann 2006.

Worms R, Griffiths R. Orthopaedic Surgery. Oxford Handbook of Anaesthesia 2nd edition. Allman KG, Wilson IH Oxford University Press 2006.

Prospect (procedure specific post op pain management). Total knee replacement. www.postoppain.org 2007

Choi PT, Bandari M, Scott J, Douketis J. Epidural analgesia for pain relief following hip or knee replacement. www.cochrane.org/reviews/en/ab003071.html

National Institute for Health and Clinical Excellence. Reducing the risk of venous thromboembolism in patients undergoing surgery.2007. www.nice.org.uk/CG046