Anesthesia for total hip arthroplasty

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Recent advances in anesthetic care for patients undergoing total hip arthroplasty are summarized. Epidural and spinal anesthesia are associated with reduced perioperative blood loss and lower deep vein thrombosis rates. A new technique of inducing hypotension with epidural anesthesia is described. This technique is associated with low rates of deep vein thrombosis, blood transfusions, and enhanced cement-bone interface. Pulmonary fat-marrow emboli can now be assessed with echocardiography and changes in pulmonary artery pressure. Management strategies are also addressed and new techniques of postoperative pain control are discussed. In the past few years, the mortality rate following total hip arthroplasty has fallen to 0.1% at The Hospital For Special Surgery in New York City using hypotensive epidural anesthesia, appropriate perioperative hemodynamic monitoring, and rational postoperative pain control.

Current Opinion in Orthopaedics 1992, 3:455–460

Techniques

Total hip arthroplasty can be performed under general, spinal, or epidural anesthesia, or combinations of these techniques. In the majority of centers, general anesthesia is primarily used, but more recently the use of epidural and spinal anesthesia has increased. Problems with regional anesthesia include lack of technical expertise in performing the blocks and the ability to sedate people in the lateral decubitus position for long periods of time.

More recently, several reports using psoas compartment block have been published [1•]. This technique entails injecting local anesthetic into the psoas muscle to anesthetize both the femoral and part of the sciatic nerves. Light general anesthesia is also used. The virtues of regional anesthesia are that patients’ airways are not compromised and blood pressure is easy to control, blood loss is less, patients have less pain postoperatively, and they generally appear to recover more readily.

Hypotensive anesthesia

Hypotensive anesthesia has been demonstrated to reduce blood loss during total hip arthroplasty in a number of studies. Typically, this has been achieved using general anesthesia with a variety of vasodilating agents [2•]. The problem with inducing hypotension with general anesthesia is that it causes a reduction in cardiac output, and the technique is not recommended for patients with underlying medical comorbidities or advanced age.

More recently, at The Hospital For Special Surgery, a technique of combining epidural anesthesia with intraoperative hypotension has been developed [3•]. This technique enables mean arterial pressure to be reduced by 50% with preservation of cardiac output. Extensive epidural anesthesia is established and circulatory stability maintained with a low-dose intravenous epinephrine infusion (1 to 5 μg/min). The epinephrine preserves cardiac output and heart rate, and appears to increase blood flow to skeletal muscle (assessed by occlusion plethysmography). The technique is usually performed using radial artery monitoring and all patients receive nasal oxygen and intravenous sedation throughout surgery. If necessary, patients can be minimally sedated to monitor brain function during the hypotension.

In a prospective study of a 983 patients, the technique was shown to be safe in patients with controlled hypertension. In this series, there were three postoperative deaths and two patients had Q-wave myocardial infarctions postoperatively [4•]. This experience compares favorably with other series of patients receiving general anesthesia with normotension. For this reason, I feel the technique is safe, if not safer than traditional anesthesia techniques.

Intraoperative blood loss for primary total hip arthroplasty using epidural hypotensive anesthesia is usu-
Intraoperative blood loss, mL

Fig. 1. The mean ±SD of the number of units of blood transfused perioperatively in 385 patients who did not predonate autologous blood prior to primary total hip arthroplasty at The Hospital For Special Surgery from 1986 to 1989. Patients who had blood losses of less than 300 mL received an average of 0.5 unit of blood.

Implications of the reduced intraoperative blood loss

One of the main reasons to provide hypotension during total hip arthroplasty is to reduce transfusion requirements. This is most important in patients who do not have autologous blood available. Figure 1 shows the mean number of transfusions in a cohort of patients who did not predonate autologous blood. These patients did not all receive hypotensive anesthesia. As can be seen, the lower the operative blood loss, the lower the mean number of transfusions. As intraoperative blood loss exceeded 700 mL, the transfusion requirements increased significantly.

Reducing intraoperative blood loss lessens the need for intraoperative fluid. The average patient undergoing primary total hip arthroplasty at The Hospital For Special Surgery receives between 1000 to 1500 mL of crystalloid during surgery. This contrasts with the previous crystalloid requirement of approximately 3000 mL when normotensive general anesthesia was used [5*]. Excessive fluid administered during surgery may predispose patients to postoperative hypoxia and potentially pulmonary edema.

The final advantage of reduced intraoperative blood loss is improvement in the quality of the cement-bone interface [6*]. It has been proposed previously that if blood could be removed from the bone surface, better impregnation of cement into cancellous bone could be achieved. In a study using matched pairs, Ranawat et al. [7*] was able to demonstrate that patients who had general anesthesia with normotension had poorer radiographic evidence of cement fixation than a matched group who received hypotensive epidural anesthesia. Perhaps this improved fixation will result in longer survival of the cemented prosthesis.

Deep vein thrombosis in anesthesia

A number of reports [8,9,10*,11] have described lower rates of deep vein thrombosis following total hip arthroplasty when either spinal or epidural anesthesia was used. More recently, lower deep vein thrombosis rates were observed using psoas compartment block [12*]. The mechanism for this reduction is not clear, but probably reflects enhanced blood flow during surgery and in the early postoperative period.

Recent experience at The Hospital For Special Surgery suggests that intraoperative management can markedly reduce the deep vein thrombosis rate following total hip arthroplasty. In a series of 381 cases of primary total hip arthroplasty performed using hypotensive epidural anesthesia, the overall rate of deep vein thrombosis was 15% [13]. Factors contributing to deep vein thrombosis were analyzed. The surgical duration and the intraoperative use of low-dose epinephrine infusions were independently associated with lower rates. The proximal deep vein thrombosis rate was 9.3% in patients who did not receive epinephrine and 2.2% in those who received a low-dose epinephrine infusion during surgery. The mechanism for this is not clear,

Fig. 2. The mean intraoperative blood loss plotted against postoperative deep vein thrombosis rates. All these studies used epidural anesthesia, and venography was used to assess deep vein thrombosis. Data from Fredin et al. [25], Modig et al. [26], Modig et al. [27], Sharrock et al. [28], Sharrock et al. [29], and Thorburn et al. [30].
but probably reflects enhancement of skeletal muscle blood flow by low-dose epinephrine.

The role of hypotension and reduced blood loss was not apparent in this study. However, it is entirely possible that by reducing blood loss and thereby preserving a normal coagulation profile intraoperatively, the hypotension could contribute to the lower deep vein thrombosis rate. In Figure 2, the relationship between deep vein thrombosis and mean intraoperative blood losses during total hip arthroplasty are seen (all these studies were performed using epidural anesthesia). There is a strong relationship between the deep vein thrombosis rate and increasing intraoperative blood loss.

In a randomized blinded study, the use of intraoperative intravenous heparin significantly reduced the deep vein thrombosis rate from 26% to 9% [14*]. The proximal clot rate was under 2% in patients receiving intraoperative heparin. All these patients received hypotensive epidural anesthesia, which minimized the likelihood of bleeding with the intraoperative heparin. Intraoperative blood loss was increased from 220 to 260 mL in the heparin group and the epidural catheter had to be placed 1 hour before surgery.

The use of low-molecular-weight heparin is gaining popularity in Europe [15**]. If these agents are given preoperatively, this probably precludes using regional anesthesia because of the ever-present risk of epidural hematoma if epidural anesthesia is used. This is a dilemma for the anesthetic community who recognizes the advantages of epidural anesthesia.

**Pulmonary emboli**

Intraoperative hypotension and perioperative hypoxemia are known complications of total hip arthroplasty [16*]. These have been attributed to the methyl methacrylate monomer or fat and bone marrow emboli. Recently, echocardiographic monitoring has demonstrated significant embolization during total hip arthroplasty [17]. These emboli occur during reaming and with insertion of both cemented and noncemented

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**Fig. 3.** An increase in pulmonary arterial pressure is demonstrated without concomitant changes in heart rate or arterial pressure, as measured by a pulmonary artery catheter. A represents insertion of the cement.
Pulmonary artery catheters may also be used to identify intraoperative pulmonary emboli (Fig. 3). When pulmonary emboli enter the pulmonary vasculature, pulmonary artery pressure increases [18]. The timing and perhaps the degree of the embolization can be characterized with pulmonary artery catheters. In our experience, about 20% to 30% of patients who have a cemented femoral prosthesis inserted have significant increases in pulmonary artery pressure shortly following insertion of the femoral prosthesis. Patients who have insertion of long-stem prostheses have the highest risk of acute circulatory collapse from acute pulmonary emboli. This may result in cardiac arrest. For these reasons we recommend monitoring those patients undergoing cemented long-stem total hip arthroplasties with arterial and pulmonary artery catheters (Fig. 4) [19*].

Hypoxemia has been described in association with total hip arthroplasty. The pathogenesis of this is not clear but probably reflects some degree of pulmonary endothelial injury. Extensive experience in the Post-Anesthesia Care Unit at The Hospital For Special Surgery suggests that the degree of hypoxia from embolization following total hip arthroplasty can be minimized by postoperative oxygen administration, epidural analgesia, fluid restriction, judicious use of diuretics, and monitoring of pulmonary artery pressure for 24 to 48 hours postoperatively.

**Postoperative analgesia**

A number of approaches to provide effective, safe, postoperative analgesia for total hip arthroplasty patients have been proposed. These include the use of intravenous patient-controlled analgesia, epidural analgesia with narcotics or local anesthetics, rectal indomethacin, and parenteral nonsteroidal agents such as ketorolac [20*]. Any of these approaches is probably preferable to intramuscular narcotics as necessary, even though patients undergoing total hip arthroplasty do not usually experience the severe pain that is seen following total knee arthroplasty. One of the potential advantages of epidural analgesia is that it may modify the metabolic response to surgery [21*,22*]. However, this theoretic benefit has never been demonstrated in terms of patient complications or improved rehabilitation rate. Perhaps the major advantage of infusion techniques or patient-controlled analgesia is that they provide a more steady, appropriate level of analgesia. Excessive or inadequate analgesia can produce adverse effects.

**Outcome**

Historically, the major cause of mortality following total hip arthroplasty has been acute pulmonary embolism, but if thromboprophylaxis is used, cardiac death is more common. Unrecognized myocardial ischemia may occur in 30% of cases and occurs mainly postoperatively [23*].
A number of studies in orthopedic patients have demonstrated improved outcome in those receiving regional rather than general anesthesia. A recent study of 150 patients in Britain who were randomly assigned to receive either spinal or general anesthesia demonstrated no difference in either outcome or in changes in cognitive function postoperatively [24]. In a retrospective review of all patients undergoing elective total hip arthroplasty at The Hospital for Special Surgery from 1981 to 1985, there was a 0.34% mortality rate using mainly general anesthesia. From 1987 to 1991 the rate was 0.10% using hypotensive epidural anesthesia. This data suggests that epidural hypotensive anesthesia is no more hazardous than normotensive anesthesia.

References and recommended reading

Papers of particular interest, published within the annual period of review, have been highlighted as:

- Of special interest
- Of outstanding interest


Blood loss during primary total hip arthroplasty was reduced from 617 to 310 mL when psoas compartment block was used.


Ketanserin, a serotonin blocker, added to general anesthesia significantly reduced intraoperative blood loss from 894 to 454 mL. This is yet another intravenous vasodilating agent that can be used to provide hypotensive anesthesia.


The technique of induced hypotension using epidural anesthesia is described. Increasing doses of low-dose epinephrine returned heart rate and cardiac output to normal even when mean arterial pressure was reduced by 50%.


This was a prospective study of almost 1000 patients who had hypertensive epidural anesthesia for total hip arthroplasty at the Hospital For Special Surgery. The technique was well tolerated. There were only two Q-wave myocardial infarcts and three deaths in this series. Patients with hypertension were found to be at no increased risk. This is the first large series demonstrating the safety of hypotensive anesthesia in elderly patients undergoing orthopaedic surgery.


This article is of utmost interest in that it demonstrates respiratory dysfunction following total joint arthroplasty using normotensive general anesthesia. Significant volumes of crystalloids were also used intraoperatively. A high incidence of perioperative hypoxemia and respiratory dysfunction was identified.


This study demonstrates a 44% reduction of bleeding into the femoral canal during reaming in patients under spinal anesthesia. Inserting freezing saline into the femur further reduced the bleeding. This is important in relation to improving the quality of the bone-cement interface.


Patients receiving hypotensive epidural anesthesia were matched with patients receiving normotensive general anesthesia. Three blinded observers demonstrated significantly better radiographic evidence of bone-cement interface of the acetabular component.


This excellent review concludes that regional anesthesia is associated with a lower deep vein thrombosis rate than general anesthesia.


These authors demonstrated a very low incidence of proximal deep vein thrombosis in patients receiving psoas compartment block concurrently with heparin. By contrast, they found a 27% proximal deep vein thrombosis rate using epidural anesthesia, which was 18% when epidural anesthesia was used with low-molecular-weight heparin.


One hundred twenty-six patients were randomly assigned to receive intraoperative intravenous heparin (1000 U/h) during total hip arthroplasty. Deep vein thrombosis was 24% in the placebo groups and 8% in the heparin group (P=0.03). One of six patients (<2%) in the heparin group had proximal deep vein thrombosis.


This is a review of a series of trials of low-molecular-weight heparin for total hip arthroplasty. The proximal deep vein thrombosis rate is about 5%. Interestingly, this rate was the same using spinal anesthesia with or without low-molecular-weight heparin postoperatively. Caution has to be exercised when administering regional anesthesia in anticoagulated patients.

Oxygen saturation may decline transiently during insertion of a cemented femoral component during total hip arthroplasty. This study demonstrates a better oxygenation by pulse oximetry in patients receiving higher inspired oxygen concentration.


Review of seven cases of acute circulatory collapse during insertion of long-stem total hip arthroplasty. The combination of cement and pressuring the distal femur may be associated with massive, potentially fatal acute fat embolism. A method of resuscitation by administering epinephrine via the distal port of a pulmonary artery catheter is described.


Sixty patients were randomly assigned to receive spinal anesthesia with or without intrathecal narcotics. Intrathecal narcotics reduced postoperative pain but other indices of outcome were not altered.


Epidural analgesia with local anesthetic maintained for 24 hours postoperatively can reduce muscle protein breakdown. These authors demonstrated that epidural anesthesia limited to the period of the operation alone does not spare protein breakdown.


Twenty-two patients were randomly assigned to receive either spinal or general anesthesia. No significant differences were noted between the groups in a whole battery of indices of the immune response to surgery.


Three-fourths of patients had evidence of myocardial ischemia on holter monitoring following total hip replacement. The majority of episodes occurred during the daytime over the first 4 postoperative days.


One hundred forty-six patients were randomly assigned to receive either spinal or general anesthesia for total hip arthroplasty. There were no differences in cognitive function, outcome, or time to discharge between groups. Incidentally, there were three in-hospital deaths (1%), which were all from pulmonary emboli, and the spinal anesthesia did not provide surgical anesthesia in six of 74 patients.


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