Safety of one-stage bilateral hip and knee arthroplasties under regional anaesthesia and routine anaesthetic monitoring

M. Schäfer, R. Elke, J. R. Young, P. Gancs, C. H. Kindler

From University Hospital Basel, Basel, Switzerland

Using a computer-based quality assurance program, we analysed peri-operative data on 160 patients undergoing one-stage bilateral hip or knee arthroplasties under regional anaesthesia with routine anaesthetic monitoring and only using peripheral intravenous access for peri-operative safety. We monitored defined intra-operative adverse events such as hypotension, myocardial ischaemia, arrhythmias, hypovolaemia, hypertension and early post-operative complications. We also determined post-operative hip and knee function, and patient satisfaction with different aspects of the anaesthetic management. Those patients undergoing one-stage bilateral arthroplasties were matched according to a cross-stratification which used three variables (American Society of Anesthesiologists’ physical status scoring system, age and joint replaced) to patients undergoing unilateral hip or knee arthroplasties. Serious intra-operative adverse events were, with the exception of intra-operative hypotension, very infrequent in patients undergoing bilateral (nine adverse events) as well as unilateral arthroplasties (five adverse events). Early post-operative complications were also infrequent in both groups. However, the risks of receiving a heterologous blood transfusion (odds ratio 2.5; 95% confidence interval (CI) 1.3 to 5.0, estimated by exact conditional logistic regression) or vasoactive drugs (odds ratio 3.9; 95% CI 2.0 to 7.8) were significantly greater for patients undergoing bilateral operations. Patient satisfaction with anaesthesia was high; all patients who underwent the one-stage bilateral operation would choose the same anaesthetic technique again.

Total hip and knee arthroplasties are common major orthopaedic procedures worldwide. Symmetrical involvement occurs frequently, necessitating a bilateral operation. Concern exists over the safety and efficacy of bilateral one-stage compared with staged or unilateral joint arthroplasties. Advantages of one-stage bilateral joint replacement are said to include a single anaesthetic, reduced overall hospitalisation, simplified rehabilitation and more efficient use of resources. Cost containment in orthopaedic surgery has become a matter for debate.

The disadvantages of one-stage bilateral arthroplasty include greater blood loss, a higher incidence of heterotopic ossification and deep-vein thrombosis. The literature has conflicting reports on the morbidity and mortality of one-stage bilateral procedures versus staged treatment. 

An overview of randomised trials indicates that regional anaesthesia reduces post-operative mortality and morbidity in a wide range of patients with little risk of serious complications with appropriate care. Regional anaesthesia has been shown to reduce both blood loss and the incidence of deep-vein thrombosis compared with general anaesthesia in elective hip and knee surgery. Furthermore, the metabolic stress response to surgery and anaesthesia is more effectively controlled by regional than general anaesthesia, as well as providing better post-operative pain control. General anaesthesia has been associated with acute post-operative confusion in elderly patients undergoing orthopaedic surgery. Regional anaesthesia may decrease the incidence of this problem. Early experience with one-stage bilateral hip replacement indicated that spinal anaesthesia may be beneficial in terms of blood loss, duration of surgery, wound healing, systemic complications and even length of hospital stay. One-stage bilateral knee arthroplasties performed under spinal anaesthesia were reported to be safe with careful patient selection. However, most publications which discuss one- versus two-stage orthopaedic procedures focus on post-operative complications and safety, with little or no emphasis on anaesthetic technique.
Recently, systematic invasive monitoring has been recommended for one-stage bilateral joint arthroplasties, including the intra-operative measurement of haemodynamic parameters for embolism and the post-operative monitoring of patients in an intensive care unit. The use of regional rather than general anaesthesia, peri-operative invasive haemodynamic monitoring including pulmonary arterial catheters and post-operative epidural anaesthesia, are linked to the reduction of mortality. Lately, serious complications of pulmonary arterial catheter placement have been described including arrhythmias, lung injury, severe pulmonary haemorrhage, thromboembolism and sepsis.

The mortality rate because of complications associated with a pulmonary arterial catheter has been estimated as between 0.02% and 1.5%. Furthermore, in a prospective cohort study into the risks and effectiveness of right-heart catheterisation, the authors concluded that pulmonary arterial catheters are not only associated with increased morbidity and mortality but also with an increased use of resources, both in terms of materials and personnel.

We undertook the present study because of accepted beneficial effects of regional anaesthesia in orthopaedic surgery and our concerns over the use of invasive monitoring. We report on 160 patients who underwent a one-stage bilateral hip or knee arthroplasty under regional anaesthesia with routine anaesthetic monitoring and peripheral intravenous access alone.

Patients and Methods

All patients who underwent one-stage bilateral arthroplasties of the lower extremities under regional anaesthesia at our institution during a ten-year period were analysed in a case control study of prospectively collected data. This cohort was matched with a control series of patients undergoing a unilateral arthroplasty during the same period. Matching was performed within a cross-stratification of three variables: the American Society of Anesthesiologists’ (ASA) physical status scoring system (ASA scores I to III), age in years (≤ 50, 51 to 60, 61 to 70, 71 to 80, ≥ 81) and joint replaced (hip or knee). Cases were found in 22 of 30 possible strata.

After approval by the local ethics committee, we used the quality assurance programme of our institution for this analysis. Pre-, intra- and post-operative data had been prospectively collected and entered into a database. Pre-operative details included demographic data as well as co-morbidities and the ASA score. The intra-operative data included the anaesthetic technique, details of all medications administered, duration of operation and anaesthesia, blood loss and transfusion requirements, and intra-operative adverse events such as hypotension, myocardial ischaemia, arrhythmias, hypovolaemia and hypertension. The clinical outcome was prospectively followed up by trained quality assurance nurses between days three and five after the operation and by the orthopaedic surgeons at three and 12 months post-operatively. On days three to five, the quality assurance nurses recorded the immediate post-operative complications such as cardiovascular complications (myocardial ischaemia, heart failure, arrhythmias, pulmonary embolism and thrombosis), respiratory complications (atelectasis, pneumonia, secondary intubation, admission to intensive care units), neurological complications (cerebrovascular accident, post-operative confusion, neurological complications after regional anaesthesia) and infection. Patient satisfaction with the anaesthetic preparation and anaesthetic technique, post-operative analgesia, and recovery from anaesthesia were assessed with a standardised questionnaire.

All patients received routine anaesthetic monitoring according to the ASA recommendations, with non-invasive blood pressure measurement, electrocardiogram, pulse oximetry, peripheral intravenous access, and were monitored post-operatively in a post-anaesthesia recovery unit for a short time before transfer to the orthopaedic ward. Total knee arthroplasties were performed under tourniquet control. In the one-stage bilateral arthroplasty groups, the procedure was started by the same team on the second joint after the first prosthesis was implanted. All patients received prophylaxis for deep-vein thrombosis using low-molecular-weight heparin. A pre-operative autologous transfusion service, an intra-operative cell saver and a filter reinfusion drain system were available. During surgery, Ringer’s lactate was infused at a rate of 150 ml/h. Additional intravenous fluids such as crystalloids, colloids, and blood were administered as dictated peri-operatively by blood loss and haemodynamic instability. Blood loss > 500 ml was replaced with a maximum of 1000 ml of 6% hydroxyethyl starch or by packed red cells if the haemoglobin was < 9 g/dl. Intra-operative hypotension was defined as a 30% reduction in mean arterial blood pressure from baseline values and was treated with 300 ml additional fluid or, if not responsive within five minutes, with intravenous ephedrine (5 mg bolus) followed by intravenous phenylephrine (50 µg bolus). All patients followed an identical physiotherapy protocol and were either discharged home or to an extended rehabilitation facility. Assessment of recovery was undertaken by orthopaedic surgeons using the modified Knee Society scoring system or the International Documentation and Evaluation System (IDES) hip questionnaire corresponding to the Merle d’Aubigné and Postel score at three and 12 months post-operatively. The cost analysis was based on total hospital charges submitted to insurance companies.

Analysis of data was by treating case-control status as the ‘outcome’ and measures of safety as ‘exposures’. We considered four measures of safety: intra-operative hypotension; the occurrence of any other serious intra-operative adverse event such as myocardial ischaemia, arrhythmias, hypovolaemia, hypertension; any heterologous blood transfusion; and any use of vasoactive drugs. For each exposure, we then estimated a common odds ratio...
across the 22 strata as a measure of the association between outcome and exposure. We used three different methods for estimating a common odds ratio. First, we reported the Cochran-Mantel-Haenszel estimate of the common odds ratio. This estimate is not entirely appropriate because it assumes a fixed number of controls per case. Secondly, we estimated the common odds ratio using conditional logistic regression because this method imposes no restriction on the numbers of cases and controls in each stratum. We reported estimates without co-variates and then with gender and body mass index as covariates. Finally, because conditional logistic regression is a large-sample method of analysis, we also estimated the common odds ratio using exact conditional logistic regression. All statistical analyses were performed using SAS version 8.2 (SAS Institute Inc., Cary, North Carolina).

### Results

During the study period, 160 patients underwent one-stage bilateral joint arthroplasties, 80 bilateral hip and 80 bilateral knee arthroplasties. The matched control group consisted of 80 patients who underwent unilateral hip arthroplasty and 55 patients who underwent unilateral knee arthroplasty. Patients’ details are shown in Table I. In the one-stage bilateral hip arthroplasty group, most procedures were performed under epidural anaesthesia. In the unilateral group, the operations were mainly performed under spinal anaesthesia. In the one-stage bilateral knee arthroplasty group, most operations were also performed under epidural anaesthesia. In the knee control group, spinal or epidural anaesthesia were used equally.

For hip arthroplasties, the duration of operation and anaesthesia was 73% and 43% longer, respectively, for

### Table I. Patients’ details

<table>
<thead>
<tr>
<th></th>
<th>Hip (n = 160)</th>
<th>Knee (n = 135)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unilateral (n = 80)</td>
<td>Bilateral (n = 80)</td>
</tr>
<tr>
<td>Age in yrs (SEM)</td>
<td>68 (1)</td>
<td>60 (1)</td>
</tr>
<tr>
<td>Body mass index in kg/m^2 (SEM)</td>
<td>26.6 (0.6)</td>
<td>26.0 (0.5)</td>
</tr>
<tr>
<td>ASA score†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>6</td>
<td>16</td>
</tr>
<tr>
<td>II</td>
<td>55</td>
<td>57</td>
</tr>
<tr>
<td>III</td>
<td>19</td>
<td>7</td>
</tr>
<tr>
<td>IV</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Spinal anaesthesia</td>
<td>70</td>
<td>15</td>
</tr>
<tr>
<td>Epidural anaesthesia</td>
<td>10</td>
<td>60</td>
</tr>
<tr>
<td>CSEA†</td>
<td>0</td>
<td>5</td>
</tr>
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</table>

* ASA score, American Society of Anesthesiologists’ physical status score
† CSEA, combined spinal-epidural anaesthesia

### Table II. Intra-operative data, volume of blood loss, transfusions and use of vasoactive drugs. Data are presented as mean (SEM)

<table>
<thead>
<tr>
<th></th>
<th>Hip (n = 160)</th>
<th>Knee (n = 135)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unilateral (n = 80)</td>
<td>Bilateral (n = 80)</td>
</tr>
<tr>
<td>Operation duration (min)</td>
<td>107 (4)</td>
<td>185 (5)</td>
</tr>
<tr>
<td>Anaesthesia duration (min)</td>
<td>188 (5)</td>
<td>269 (5)</td>
</tr>
<tr>
<td>Autologous blood donation (ml)</td>
<td>506 (61)</td>
<td>597 (42)</td>
</tr>
<tr>
<td>Blood loss (ml)</td>
<td>917 (56)</td>
<td>1451 (62)</td>
</tr>
<tr>
<td>Cell saver + filter reinfusion (ml)</td>
<td>949 (242)</td>
<td>806 (60)</td>
</tr>
<tr>
<td>Heterologous transfusion (ml)</td>
<td>548 (54)</td>
<td>1040 (79)</td>
</tr>
<tr>
<td>Ephedrine (mg)</td>
<td>18 (2)</td>
<td>25 (2)</td>
</tr>
<tr>
<td>Phenylephrine (µg)</td>
<td>153 (29)</td>
<td>238 (24)</td>
</tr>
</tbody>
</table>

### Table III. Number of patients receiving blood transfusions and vasoactive drugs

<table>
<thead>
<tr>
<th></th>
<th>Hip (n = 160)</th>
<th>Knee (n = 135)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unilateral (n = 80)</td>
<td>Bilateral (n = 80)</td>
</tr>
<tr>
<td>Autologous blood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>9</td>
<td>30</td>
</tr>
<tr>
<td>No</td>
<td>71</td>
<td>50</td>
</tr>
<tr>
<td>Cell saver</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>8</td>
<td>39</td>
</tr>
<tr>
<td>No</td>
<td>72</td>
<td>41</td>
</tr>
<tr>
<td>Heterologous blood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>23</td>
<td>30</td>
</tr>
<tr>
<td>No</td>
<td>57</td>
<td>50</td>
</tr>
<tr>
<td>Ephedrine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>53</td>
<td>74</td>
</tr>
<tr>
<td>No</td>
<td>27</td>
<td>6</td>
</tr>
<tr>
<td>Phenylephrine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>No</td>
<td>68</td>
<td>76</td>
</tr>
</tbody>
</table>
patients having one-stage bilateral arthroplasties compared with those having a unilateral procedure. Similarly, in knee surgery, the duration of operation and anaesthesia was 68% and 42%, respectively, longer for bilateral arthroplasties (Table II). Blood loss was also higher in patients undergoing one-stage bilateral hip or knee arthroplasties (Table II). The odds of receiving a heterogenous blood transfusion were approximately 2.5 times greater for bilateral procedures than for unilateral procedures (Tables III and IV). As expected, autologous blood donation was used more often in patients scheduled for bilateral hip arthroplasties than in patients undergoing a unilateral procedure (Table III). The odds of vasoactive drug use were approximately four times greater during bilateral operations (Tables III and IV).

With respect to intra-operative adverse events, only intra-operative hypotension occurred regularly and there is some evidence that it was more frequent in patients undergoing one-stage bilateral arthroplasties (odds ratio 1.5, 95% confidence interval [CI] 0.8 to 3.0, exact conditional logistic regression) (Tables IV and V). Other serious intra-operative adverse events such as myocardial ischaemia, arrhythmias, hypovolaemia, and hypertension, were very infrequent in both groups of patients undergoing bilateral and unilateral arthroplasties, with only nine and five such events, respectively (Table V). The odds of these intra-operative adverse events were not significantly different between cases and controls, but there were large confidence intervals because of the infrequency of these events (Table IV). With respect to early post-operative complications, only one patient in the unilateral knee arthroplasty group suffered from a post-operative pulmonary embolism. For each measure of safety estimates of the common odds ratio were similar regardless of the method of analysis (Table IV).

The length of hospital stay of patients receiving a one-stage bilateral hip arthroplasty were only slightly longer than for those having a unilateral procedure (Table VI). One-stage bilateral hip and knee arthroplasties were 15% and 25%, respectively, less costly than two unilateral hip or knee arthroplasties (Table VI). There were no obvious differences between groups in post-operative function scores with the modified Knee Society scoring system and IDES hip questionnaire. The overall satisfaction of the patients with their anaesthetic care was also very high in both bilateral arthroplasty groups while all patients who underwent a one-stage bilateral operation reported they would choose the same regional anaesthetic technique again.

**Discussion**

The results of our study show that one-stage bilateral hip and knee arthroplasties were performed safely under regional anaesthesia with only routine anaesthetic monitoring and peripheral venous access. Although higher morbidity and mortality of one-stage bilateral joint arthroplasties has been reported when inadequate consideration is given to pre-existing comorbidities, these procedures are generally considered beneficial to patients when the indications are appropriate. However, extensive anaesthetic monitoring using central lines or pulmonary arterial catheters as

**Table IV.** Odds ratios and 95% confidence intervals (CI) for four safety outcomes of interest according to three different methods of analysis for patients undergoing one-stage bilateral arthroplasties versus patients undergoing unilateral arthroplasty

<table>
<thead>
<tr>
<th>Analysis method</th>
<th>Cochran-Mantel-Haenszel** estimate</th>
<th>Conditional logistic regression</th>
<th>Conditional logistic regression (after adjusting for covariates)*</th>
<th>Exact conditional logistic regression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intra-operative hypotension</td>
<td>1.6 (0.8 to 2.9)</td>
<td>1.5 (0.8 to 2.9)</td>
<td>1.5 (0.8 to 2.9)</td>
<td>1.5 (0.8 to 3.0)</td>
</tr>
<tr>
<td>Other serious intra-operative adverse event†</td>
<td>1.3 (0.4 to 4.3)</td>
<td>1.3 (0.4 to 4.4)</td>
<td>1.4 (0.4 to 4.8)</td>
<td>1.3 (0.4 to 5.6)</td>
</tr>
<tr>
<td>Any heterologous blood transfusion</td>
<td>2.5 (1.3 to 4.6)</td>
<td>2.5 (1.4 to 4.7)</td>
<td>2.4 (1.3 to 4.7)</td>
<td>2.5 (1.3 to 5.0)</td>
</tr>
<tr>
<td>Any use of vasoactive drugs</td>
<td>4.2 (2.2 to 8.1)</td>
<td>3.9 (2.1 to 7.3)</td>
<td>4.1 (2.0 to 8.2)</td>
<td>3.9 (2.0 to 7.8)</td>
</tr>
</tbody>
</table>

* covariates were gender and body mass index
† other serious intra-operative adverse events include myocardial ischaemia, arrhythmias, hypovolaemia and hypertension

**Table V.** Number of patients suffering from intra-operative adverse events

<table>
<thead>
<tr>
<th></th>
<th>Hip (n = 160)</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unilateral</td>
<td>Bilateral</td>
</tr>
<tr>
<td></td>
<td>(n = 80)</td>
<td>(n = 55)</td>
</tr>
<tr>
<td>Hypotension</td>
<td>23</td>
<td>24</td>
</tr>
<tr>
<td>Myocardial ischaemia</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Arrhythmias</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Hypovolaemia</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Hypertension</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

**Table VI.** Length of hospital stay and hospital costs. Data are presented as mean (SEM)

<table>
<thead>
<tr>
<th></th>
<th>Hip (n = 160)</th>
<th>Knee (n = 135)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unilateral</td>
<td>Bilateral</td>
</tr>
<tr>
<td></td>
<td>(n = 80)</td>
<td>(n = 80)</td>
</tr>
<tr>
<td>Hospital stay in days</td>
<td>19 (1)</td>
<td>23 (1)</td>
</tr>
<tr>
<td>Hospital costs*</td>
<td>19 537 (1172)</td>
<td>33 875 (1913)</td>
</tr>
</tbody>
</table>

* Swiss francs
suggested in the literature during one-stage bilateral joint arthroplasties must be reconciled with concerns expressed over the increased morbidity and mortality associated with such invasive monitoring.

Concerns have been expressed about greater blood loss and higher transfusion requirements in a one-stage bilateral procedure. The blood loss of staged bilateral arthroplasties is approximately double that of a unilateral procedure but the blood loss from one-stage bilateral knee arthroplasties is greater from the second knee, possibly because of a decrease in clotting factors, the effect of increased tourniquet time, tissue trauma, or hypothermia. As expected, we found blood loss was higher in both bilateral groups but in the bilateral hips it was less than twice that of the unilateral group. Consistent with a previous study, the blood loss during bilateral knee arthroplasties was more than double that of a unilateral knee operation. Our results show that the risk of heterologous blood transfusion remains a concern and pre-operative autologous blood donation should be proposed for one-stage bilateral procedures and that blood conservation methods be considered.

Despite some evidence of more frequent intra-operative hypotension in patients undergoing bilateral arthroplasties (odds ratio 1.5, 95% CI 0.8 to 3.0), intra- and early post-operative neurological or cardiovascular complications were infrequent for both bilateral and unilateral operations. The finding is consistent with the results of a previous study showing no morbidity associated with arterial hypotension in patients undergoing total hip arthroplasty under spinal anaesthesia. Only one patient undergoing one-stage bilateral knee arthroplasties presented with intra-operative myocardial ischaemia. In contrast with other studies, none of the patients suffered from congestive heart failure or confusion in the early post-operative period. It has been postulated that the prolonged duration of surgery and anaesthesia were associated with increased atelectasis and fluid overload, resulting in vascular congestion, especially in the elderly population. However, in our study, the durations of operation and anaesthesia were obviously longer in the one-stage arthroplasty groups but not twice as long as the respective unilateral procedure.

While it may seem surprising to consider bilateral or unilateral operations as the outcome and measures of safety as the exposure, odds ratios do not change regardless of which variable is considered the response and which is considered explanatory. Using bilateral or unilateral operations as the outcome allows us to add covariates, such as gender and body mass index, to a conditional logistic regression analysis, or to use additional continuous measures of safety. In estimating the common odds ratio, we pooled information for both hip and knee operations. This offers a powerful analysis of our most important measure of safety (serious intra-operative adverse events other than hypotension). However, our study did not have the power to detect or rule out a difference between bilateral and unilateral procedures because of the infrequency of these serious adverse events.

The length of hospital stay was only slightly longer for patients having one-stage bilateral arthroplasties compared with patients having a unilateral operation, producing a saving of hospital resources. However, our orthopaedic institution provided extended in-patient rehabilitation for some patients which explains the rather lengthy hospital stay. The cost savings of performing one-stage bilateral arthroplasties compared with performing two unilateral arthroplasties were of a similar order to those reported in previous studies.

In summary, the results of our study show that one-stage bilateral hip and knee arthroplasties can be performed safely with respect to intra- and early post-operative complications, expeditiously and cost-effectively under regional anaesthesia with only routine anaesthetic monitoring and peripheral intravenous access. The performance of one-stage bilateral arthroplasties has previously been shown to reduce general health care costs. In addition, the use of regional anaesthesia with only routine monitoring for one-stage bilateral operations is safe, reduces turnover times, saves operating theatre resources and provides patient satisfaction.

We would like to thank Joan Etlinger for editorial assistance. No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References


