Haemodynamic effects of the lateral decubitus position and the kidney rest lateral decubitus position during anaesthesia

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We measured the haemodynamic effects of changing from the supine position to the lateral decubitus (lateral) position, and then to the kidney rest lateral decubitus (kidney) position in 12 patients undergoing nephrectomy under isoflurane anaesthesia. Eight control patients undergoing pulmonary surgery remained in the lateral position. The lateral position produced no significant changes. In the kidney position, however, significant reductions occurred in the mean arterial ($P < 0.01$), right atrial ($P < 0.05$) and pulmonary artery wedge pressures ($P < 0.01$). There were also significant reductions in cardiac index (from $3.04 \pm 0.21$ to $2.44 \pm (0.26)$ litre min$^{-1}$ m$^{-2}$, $P < 0.01$) and stroke volume index (from $40 (5)$ to $31 (5)$ ml beat$^{-1}$ m$^{-2}$, $P < 0.01$). The systemic vascular resistance index increased significantly ($P < 0.05$). Cardiac output was probably reduced by a decrease in venous return and an increase in systemic vascular resistance.

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Postural changes during anaesthesia can cause haemodynamic changes with decreases in arterial pressure and cardiac output. For example, the head-up or sitting position can reduce cardiac output.$^{1-3}$ However, the effects of the lateral decubitus position (lateral position) on cardiac output in awake non-pregnant patients are not clear.$^{4-9}$ Little attention is paid to the effects of the lateral position on cardiac output in healthy subjects other than pregnant women. We know of only one report on the effect of the lateral position in anaesthetized subjects, but measurements were not made in the supine position.$^{10}$ The kidney rest lateral decubitus position (kidney position) is commonly used during surgery, and no reports have studied the effects of this position on circulatory variables that might be affected by general anaesthesia.

In the kidney position, patients are placed on their side and arched over a ‘kidney rest’ in the table with the lower hip flexed. The kidney position, therefore, could cause some blood pooling in the lower extremities. In addition, a ‘kidney rest’ and flexion of the trunk could compress the large blood vessels. The reduced venous return would decrease the filling pressure and cardiac output.

We examined the haemodynamic effects of changing from the supine position to the lateral position, and then to the kidney position in patients under isoflurane anaesthesia. We also examined the haemodynamic effects in a time-control group, who were kept in the lateral position a longer time to show that the changes in the kidney position were not caused by the passage of time.

Patients and methods

Institutional and ethics committee approvals were obtained, and all participants gave their informed consent. Twenty adult patients (ASA physical status I and II) were included in this study. Twelve of them were scheduled for nephrectomy (kidney group), and the other eight were scheduled for a lung operation (lung group). In the kidney group, six of the 12 underwent right nephrectomy, and the other six underwent left nephrectomy. None of them had cardiovascular diseases or received any medication with haemodynamic effects. The patients were premedicated with hydroxyzine, 50 mg i.m., 1 h before the induction of anaesthesia. Venous and radial arterial cannula were inserted during preoxygenation. Anaesthesia was induced with midazolam, 0.08 mg kg$^{-1}$, and fentanyl, 2 µg kg$^{-1}$, i.v., and with inhaled isoflurane and nitrous oxide in oxygen via a semi-closed system. After intratracheal application of 5 ml of 4%
lidocaine, orotracheal intubation was performed using vecuronium as a muscle relaxant. Anaesthesia was maintained with 0.8% end-tidal isoflurane and 50% nitrous oxide in oxygen. Ventilation was controlled with a tidal volume of 8–10 ml kg\(^{-1}\) to maintain the \(P_{\text{aCO}}\)\(_2\) between 35 and 40 mm Hg.

A thermodilution pulmonary arterial catheter was placed via the right internal jugular vein after the induction of anaesthesia. Chest x-rays were performed to check the position of the catheter. With the patient in the supine position, pressure transducers were referenced to the mid-axillary line at the fourth intercostal space; while the patient was in the lateral position, the transducer was placed level with the junction of the fourth intercostal space and the midsternal line. This is the left atrial level in the lateral position, as described by Kennedy et al.\(^{11}\) Continuous monitoring of \(P_{\text{EO}}\), \(P_{\text{ECO}}\), and the end-tidal isoflurane concentration was performed at the tracheal tube with the Datex Capnomac (Datex, Helsinki, Finland). The ECG and the arterial and venous pressures were continuously monitored and recorded.

Measurements were made first with the patient in the supine position. Then all patients were placed in the lateral position on a flat table. In the kidney group, six of the 12 were placed in the right lateral position, and the other six were placed in the left lateral position. A small support was placed just caudal of the dependent axilla to lift the thorax enough to prevent disturbed blood flow to the hand. The dependent leg was flexed at the hip and knee to stabilize the torso, and a proper head support and leg pillows were added. The second set of measurements was made 5 min after changing the position to lateral.

In the kidney group, patients were then placed in the kidney position (Fig. 1). In this position, the dependent iliac crest is over the hinge between the back and thigh sections of the table, and an elevated rest (kidney rest) is used under this crest. The table top was angulated by 30° to increase the amount of lateral flexion and improve access to the kidney. The third set of measurements was performed 5 min after this change of position. In the lung group, the patients remained in the lateral position, and the third measurements were performed to see if the changes after moving to the kidney position were simply caused by the passage of time. The third measurements in the lung group were taken 10 min after the second measurements because the third measurements in the kidney group were performed about 10 min after the second measurements.

Lactated Ringer’s solution was infused at a rate of 20 ml kg\(^{-1}\) h\(^{-1}\) until the first measurement, and the rate of infusion was kept to a minimum during the measurements. The haemodynamic variables measured in all patients were systolic and diastolic arterial pressures, right atrial pressure (RAP), pulmonary artery systolic and diastolic pressures, pulmonary artery wedge pressure (PAWP), cardiac output (CO) and heart rate (HR). We calculated the mean arterial pressure (MAP), pulmonary artery mean pressure (PAMP), cardiac index (CI), stroke volume index (SVI), systemic vascular resistance index (SVRI) and pulmonary vascular resistance index (PVRI). Cardiac output was measured using the thermodilution technique. Three measurements were made in each position using 10 ml of rapidly injected iced saline and the three measurements were averaged. To avoid the influence of ventilator cycles, measurements were performed at end-expiration.

**Statistical analysis**

Data are expressed as mean (SD). Data analysis was performed on a Power Macintosh using Excel 98 and StatView (Version 5). Patients’ characteristics were compared using unpaired \(t\)-test between groups. Haemodynamic measurements in each position were compared using two-way analysis of variance followed by Duncan’s method between and within groups. Values were considered statistically significant when \(P<0.05\).

**Results**

Patients’ characteristics were similar in the two groups (Table 1). In the kidney group, the postural change from the supine position to the lateral position produced no significant changes in the haemodynamic values (Fig. 2). After the patients were placed in the kidney position, significant reductions in MAP, RAP, PAMP and PAWP were observed, and there was a significant reduction in CI and SVI. HR did not change significantly during the
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Fig 2 The effect of the postural change on haemodynamic measurements in the kidney and lung groups. Measurements were made first with the patient in the supine position (Supine). Then the patients were placed in the lateral decubitus position for the second measurements (Lateral) followed by the kidney rest lateral decubitus position (Kidney) in the kidney group or the lateral decubitus position (Lateral) in the lung group for the third measurements.

HR, heart rate; MAP, mean arterial pressure; RAP, right atrial pressure; PAWP, pulmonary artery wedge pressure; CI, cardiac index; SVI, stroke volume index; SVRI, systemic vascular resistance index; PVRI, pulmonary vascular resistance index. Values are mean (SD), n=12 (the kidney group), n=8 (the lung group). *P<0.05 vs Supine and Lateral, **P<0.01 vs Supine and Lateral, ¶P<0.05 vs the lung group, ¶¶P<0.01 vs the lung group.

Table 1 Patient characteristics. Values are mean (SD or range) [95% confidence interval]. No significant differences

<table>
<thead>
<tr>
<th></th>
<th>Kidney group</th>
<th>Lung group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>12 (7, 5)</td>
<td>8 (5, 3)</td>
</tr>
<tr>
<td>(men, women)</td>
<td>56 (10) [50–62]</td>
<td>60 (8) [53–67]</td>
</tr>
<tr>
<td>Age (yr)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height (cm)</td>
<td>164 (8) [159–169]</td>
<td>162 (8) [155–169]</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>64 (9) [58–70]</td>
<td>64 (9) [56–72]</td>
</tr>
</tbody>
</table>

measurments. After changing to the kidney position, SVRI but not PVRI increased significantly. The haemodynamic variables were similar between the right and left lateral positions and between the right and left kidney positions. In the lung group, the haemodynamic values did not change significantly throughout the measurements (Fig. 2). Between the kidney and the lung groups, there were significant differences in the third measurements with regard to RAP, PAWP, CI, SVI and SVRI.

Discussion

Turning the patients from the lateral to the kidney position caused significant haemodynamic changes. These changes did not occur after changing from the supine to the lateral
position, and maintaining the lateral position for extra time did not cause any significant change in the haemodynamic variables. These findings indicate that the kidney position itself has a significant effect on haemodynamic changes.

To determine the effect of the kidney position, Pansard et al. measured arterial to end-tidal carbon dioxide tension differences (Pa-ET\(_{\text{CO}}\)) during anaesthesia. They administered anaesthetic agents as required to avoid variations in MAP >10% of stabilized values. The kidney position caused a significant increase in Pa-ET\(_{\text{CO}}\). They speculated that right filling pressure or CO, or both, which were not monitored, may have decreased because changes in either of these two variables can induce alterations in alveolar dead space.

Our results clearly show that CO decreased in the kidney position. Although we could not assess how the kidney position decreased CO, one mechanism would be a reduction in the venous return. The kidney position places the heart at a hydrostatic level above the lower extremities, which can reduce the venous return to the heart. In addition, the ‘kidney rest’ and flexion of trunk may have compressed the great vessels in the abdomen and disturbed the venous return. The decrease in RAP and PAWP in the kidney position indicated a reduction in the venous return and the resultant decrease in the preload. Although the changes in RAP and PAP were significant, they were quite small, and it is unlikely that the reduction of preload was the only factor contributing to the decrease in CO. Our results showed that the increase in SVRI was also significant and this could certainly contribute to a reduction in CO. It seems likely that the combination of a decrease in the preload and an increase in the afterload resulted in a decrease in the stroke volume and CO, thereby leading to a decrease in MAP. Echocardiography and central aortic pressure monitoring to assess cardiac preload, afterload and cardiac function would be helpful to confirm these possibilities.

In the conscious subject, reflex increases in HR and/or SVR would compensate for the decrease in MAP. In the present study, however, HR did not change significantly during the postural changes indicating that autonomic reflexes were not sufficient. Baroreflex sensitivity is preserved at 0.5 MAC isoflurane but diminished at 1.0 MAC isoflurane, and midazolam15 and fentanyl also depress the baroreflex. Although we administered only small doses of midazolam and fentanyl about 30 min before the measurements and maintained anaesthesia with 0.8% (0.67 MAC) isoflurane, these drugs might influence the baroreflex.

There are conflicting data about the effects of the supine and lateral positions on CO in non-pregnant human subjects. Investigators have used different techniques to measure CO or have studied patients in different haemodynamic circumstances. Atkins et al.,5 using impedance plethysmography, and Newman et al.,7 using a Doppler flowmeter, showed that CO was higher in the supine than in the left or right lateral positions. However, Ueland et al.,4 using dye dilution, found that CO was similar in the supine and lateral positions. Using thermodilution, Whitman et al.6 and Doering and Dracup8 reported a slightly higher CO in the left lateral than in the supine or right lateral positions, but their findings were based on data obtained from patients immediately after cardiac surgery.

Recently, Lange et al.,9 using thermodilution, observed that CO was similar in the supine and lateral positions in patients whose haemodynamics were stable. Our data, obtained with a thermodilution technique during general anaesthesia, showed that CO was similar in the supine and lateral positions. In haemodynamically stable patients, the lateral position had no clinical effect on haemodynamic variables, even under general anaesthesia. We also found similar measurements in the right and left lateral positions. Recently, Fujise et al.10 reported that MAP, RAP, PAMP and PAWP in the right lateral position were greater than in the left lateral position, but they did not make measurements in the supine position. We speculate that there could have been differences between subjects in the supine position.

In the supine position, we placed the transducer at the level described by Winsor and Birch.16 In the lateral position, we used the reference level described by Kennedy et al.11 With chest roentgenography, the left atrial level was identified anteriorly at the fourth intercostal space along the midsternal line in the lateral position. Using the lateral left atrial levels, Kennedy et al.11 detected no significant difference between PAP recorded with patients in the lateral position and pressure recorded with patients in the supine position. On the anterior–posterior view of chest roentgenogram in the supine position, the right atrium is at almost the same position as the left atrium, that is, at the fourth intercostal space along the midsternal line. We believe that the fourth intercostal space along the midsternal line will be the reference level of RAP in the lateral position.

In conclusion, our results show that the kidney position during isoflurane anaesthesia causes a significant reduction in CO and MAP.

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