Original Article

Effect of laryngeal mask airway placement on the optimal site and success rate of venipuncture via the right internal jugular vein

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Received April 29, 2015; Accepted July 7, 2015; Epub August 15, 2015; Published August 30, 2015

Abstract: The placement of a laryngeal mask airway (LMA) changes the relative positions of the common carotid artery (CCA) and right internal jugular vein (IJV), thereby affecting venipuncture via the right IJV. Therefore, we went on to determine the optimal site for puncturing the IJV after LMA-Supreme™ placement. In this study, forty-six patients were placed with a LMA-Supreme™ (size 3 or 4), and the right IJV was punctured at either of the three points (anterior, middle or posterior point). The CCA diameters and overlap between the right IJV and CCA were recorded before and after the LMA-Supreme™ placement. Finally, the success rates of IJV puncturing at the three aforementioned points were compared. We found that the size of the LMA-Supreme™ had no effect on patient respiration during the procedure. Overlap between the right IJV and CCA at the anterior and middle points was significantly increased after size 3 LMA-Supreme™ placements; Size 4 masks decreased the CCA diameters at the middle and posterior points, and significantly increased overlap between the right IJV and CCA at all the three points; IJV punctures performed after placement of size 3 LMA-Supreme™ had higher success rate than those performed after placement of size 4 masks, and were less likely to result in accidental arterial puncture. In conclusion, our study demonstrated that placement of size 3 LMA-Supreme™ caused little change in overlapping between the right IJV and CCA and the incidence of accidental arterial puncture; particularly for punctures performed at the posterior point. Therefore, we recommend venipuncture at the posterior point after placement of a LMA-Supreme™.

Keywords: Central vein catheterization, right internal jugular vein, common carotid artery, laryngeal mask airway, LMA-Supreme

Introduction

In clinical anesthesia, an induction anesthesia is usually performed prior to catheterization so as to reduce tension and pain in a patient receiving central vein catheterization (CVC). CVC via the right internal jugular vein (IJV) is commonly performed in a variety of medical procedures. A complication rate of around 10-15% has been found to be associated with CVC [1]. For CVC via the right IJV, the “central landmark” [2] is generally used. But such landmark-dependent technique of puncture has been linked to inadvertent trauma rate of 5-10% that even includes common carotid artery (CCA) puncture along with a failure rate of 4-33% [3, 4]. Although lower risks have been predicted for severe complications such as arterial bleeding and pneumothorax for CVC insertion via the UV as compared to insertion through the subclavian vein, however, the safety of a right-sided approach has been supported only by a few reports. A right-sided approach is commonly used for CVC via the IJV [1, 2]. As compared to the left-sided approach, this method involves the insertion of a shorter catheter; also a much reduced thoracic duct injury risk is associated. Besides, both the depth and diameter of the UV vary considerably between the insertions through left and right sides according to information obtained from ultrasound-guided CVC insertion [6, 7]. Similarly, the relationship between CCA and IJV is well established [8, 9]. Compression resulting from placement of a laryngeal mask airway (LMA) may displace structures in the neck [10, 11]. Following the placement of LMA, the anatomy and positional relationship between the UV and
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CCA changes in a manner that increase both the difficulty of IJV puncturing and the risk of accidentally puncturing the CCA and surrounding tissues. Overall, following the LMA placement, right IJV catheterization may be more difficult due to overlap of CCA and IJV, problem in palpating the CCA, sternocleidomastoid muscle displacement to act as a principal landmark; often causing iatrogenicity [12, 13]. In the absence of LMA placement, the central landmark accuracy for catheterization of right IJV was evaluated by Bailey et al. [14] while Takeyama et al. [4] observed increase in overlapping of the IJV and CCA following the placement of LMA-Classic; however, the vessel positioning remain unaffected at the lower puncture point. Therefore, in order to avoid CCA puncture ultrasound guidance was advised during IJV puncture at middle or high points [4]. There was also a report that suggested the failure of the central landmark after the ProSeal LMA placement in providing a good success rate at the first attempt of puncturing [15]. Although the use of an ultrasound scanner decreases the risk of complications during IJV puncturing [16, 17], puncturing done after LMA placement still carries a higher risk of CCA malpuncture as compared to puncturing done with the aid of conventional catheterization; and the patient in a waking state [18, 19]. We conducted this study to determine the optimal site for puncturing the right IJV after placement of two different sizes of LMA-Supreme™.

Patients and methods

Patients

This study enrolled 46 patients (American Society of Anesthesiologists physical status II or III; 23 men and 23 women) scheduled to undergo kidney transplantation. The 46 enrolled patients were randomly assigned to two groups. Patients in group A (n = 22) received a LMA-Supreme™ size 3, and patients in group B (n = 24) received an LMA-Supreme™ size 4. Patients who had not fasted prior to surgery or had a BMI ≥ 30 kg/m² were excluded from the study.

The patients were explained regarding the purpose of the study before they underwent through the procedure. Prior to enrollment, all the patients provided their written informed consent to have their clinical information stored in the hospital database and used for purposes of research. Study design

To minimize the risk of regurgitation, all the patients were requested not to eat for 8 h or drink for 4 h before the commencement of surgery. All the patients received routine monitoring (ECG, BP and SpO2) following their entry into the surgical suite.

Measurements were taken for the distances between the rim of the midpoint of the upper segment of thyroid cartilage and the thyroid cartilage at the level of the CCA (M), and between the upper rim of the thyroid cartilage and the jugular notch (N). Prior to LMA-Supreme™ placement, each patient was placed on a horizontal bed, and the patient’s head was rotated 30° to the left from midline [7]. The strategy was taken to prevent a portion of the probe from contacting the clavicle, and not allowing it to effectively push against the measurement site.

Three points were selected for puncturing the right IJV: an anterior point (at the edge level of thyroid cartilage, anterior of the sternocleidomastoid muscle, 0.5 cm lateral of the carotid artery); a middle point (triangle vertex level of the sternocleidomastoid muscle); a posterior point (at the lower 1/3 crossing point of the lateral border of the sternocleidomastoid muscle,
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Table 1. Patient baseline information

<table>
<thead>
<tr>
<th>Group</th>
<th>Cases</th>
<th>Age (yr)</th>
<th>Gender (m/f)</th>
<th>Weight (kg)</th>
<th>Height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>22</td>
<td>45.5 ± 14.8</td>
<td>9/13</td>
<td>62.8 ± 4.5</td>
<td>163.5 ± 7.6</td>
</tr>
<tr>
<td>B</td>
<td>24</td>
<td>42.8 ± 11.5</td>
<td>14/10</td>
<td>66.1 ± 3.8</td>
<td>170.5 ± 9.2</td>
</tr>
</tbody>
</table>

approximately two horizontal fingers above the clavicle). These three points were selected because they had all been previously used as a central venous puncture site (Figure 1A). A Doppler ultrasound scanner (iLooK 25; SonoSite Inc., Bothell, WA, USA) operated by an experienced anesthesiologist was used as a guide for proper positioning. The ultrasonic probe was placed vertical to the vessels, touching the sternocleidomastoid muscle to permit detection of the anterior, middle, and posterior points of the right CCA and right IJV. The diameter of the CCA, the distance between the two vessels, and the positional relationship between the IJV and CCA, were measured before and after LMA-Supreme™ placement (Figure 1A, 1B). The overlap rate was calculated as follows: overlap index = [overlapping (mm)/CCA diameter (mm)] × 100% (Figure 1).

The patients were intravenously injected with fentanyl (2 µg/kg), propofol (2 mg/kg), and cisatracurium (0.06 mg/kg) to induce anesthesia. The back of each laryngeal mask was lubricated and then slowly inserted into the body via its curve until resistance was felt; after which, air (5-10 mL) was injected into the cuff, and mechanical ventilation initiated. A successful placement of the LMA-Supreme™ was indicated by the following signs: a symmetrically fluctuating bilateral thorax, an absence of air leakage from the drain tube or mouth, a peak inspiratory pressure < 20 cm H2O, an absence of noise, the phonic clarity of double lung breathes, and a regular fluctuation of PET CO2. If air leakage was detected, we continuously injected 2-5 mL of air until no more leakage could be detected and the inside pressure became < 60 cm H2O. The following respirator settings were used for both the groups of patients: tidal volume (VT = 8 mL/Kg; breathing rate = 10 times/min; inspiratory time to/expiratory time ratio = 1:2. Next, ultrasound scans were taken and IJV puncturing was randomly performed via the anterior, middle or posterior points. Ten patients were implanted with a floating catheter (two punctures) because their ejection fractions prior to surgery were ≤ 50%.

Study parameters were recorded at three time points during the surgery. The first time point (T1) was immediately following placement of the LMA-Supreme™; the second time point (T2) was 3 min after placement of LMA-Supreme™, and the third time point (T3) was immediately prior to removal of the LMA-Supreme™. The recorded parameters included the tidal volume, partial pressure of carbon dioxide in end-expiratory gas, and peak inspiratory pressure. After placing the LMA-Supreme™, the positional relationship between the IJV and CCA was measured by ultrasound detection. The CCA diameter and the distance between the two vessels were measured, and used to calculate the overlap index.

Statistical analysis

CCA diameters and overlap indices were compared between (1) group A patients before and after LMA-Supreme™ placement; (2) group B patients before and after LMA-Supreme™ placement; (3) group A and group B patients after LMA-Supreme™ placement. Additionally, the success rates of venipuncture via the right IJV in group A and B patients were also compared. The data were analyzed using SPSS Statistics (Windows Version 17.0. Chicago, IL: SPSS Inc) and results are expressed as the mean value ± standard deviation (SD). Differences in overlap indices and CCA diameters within the same patient before and after LMA-Supreme™ placement were assessed by the t-test. P-values < 0.05 were considered statistically significant.

Results

Patient baseline information

Table 1 shows patient baseline information for age (group A, 45.5 ± 14.8 yr; group B, 42.8 ± 1.5 yr), gender (group A, 9/13; group B, 14/10; male/female), weight (group A, 62.8 ± 4.5 kg; group B, 66.1 ± 3.8 kg), and height (group A, 163.5 ± 7.6 cm; group B, 170.5 ± 9.2). The two study groups did not show a significant difference in any of these parameters.
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Effect of LMA-Supreme™ placement on respiration

We analyzed the respiratory changes observed in the two groups of patients. The two groups showed no significant differences in the measurements of tidal volume (Vₜ), peak inspiratory pressure (PIP) or PₖCO₂ (Table 2).

Effect of LMA-Supreme™ placement on overlapping between the right IJV and CCA

We found that without placement of the LMA-Supreme™, the two groups showed no significant difference in CCA diameter, the distance between the CCA and UV vessels, or the overlap indices between the anterior, middle, and posterior points. After placing the airway, the patients who received a size 3 LMA-Supreme™ showed significant increase in their CCA-IJV distance and overlap indices at the anterior and middle points, but no changes were observed at the posterior point. Group B patients who received the size 4 LMA-Supreme™ showed significant change at the posterior point (from 43 ± 28% to 54 ± 26%). However, placement of a size 4 LMA-Supreme™ increased the overlap indices at all the three points (anterior point, from 23 ± 17% to 78 ± 10%; middle point, from 37 ± 16% to 95 ± 5%; posterior point, from 40 ± 20% to 75 ± 9%). The increase at the middle point was greater than those at the anterior and posterior points. Thus, the size 3 mask affected the overlap index less than size 4 mask, and did not significantly affect the overlap index at the posterior point. The effects of the size 3 and size 4 LMA-Supreme™ on the overlap indices were not related to the patient’s neck length or the distance between the right CCA and cervical anterior midline (Table 3).

Effect of LMA-Supreme™ placement on IJV puncturing

Lastly, we compared the two groups for their respective rates of successful punctures performed at the posterior point. Patients with a size 4 mask as compared to those in patients with a size 3 mask. The two groups showed no significant difference in overlap index at the anterior point.

Our study showed that the placement of a size 3 LMA-Supreme™ increased the overlap indices at the anterior (from 30 ± 22% to 70 ± 24%) and middle (from 30 ± 29% to 75 ± 25%) points, while there was no significant change at the posterior point (from 43 ± 28% to 54 ± 26%). However, placement of a size 4 LMA-Supreme™ increased the overlap indices at all the three points (anterior point, from 23 ± 17% to 78 ± 10%; middle point, from 37 ± 16% to 95 ± 5%; posterior point, from 40 ± 20% to 75 ± 9%). The increase at the middle point was greater than those at the anterior and posterior points. Thus, the size 3 mask affected the overlap index less than size 4 mask, and did not significantly affect the overlap index at the posterior point. The effects of the size 3 and size 4 LMA-Supreme™ on the overlap indices were not related to the patient’s neck length or the distance between the right CCA and cervical anterior midline (Table 3).

Discussion

Patients receiving general anaesthesia and endotracheal intubation can experience a stress response that produces clinical symptoms including sympathetic stimulation, tachycardia and elevated blood pressure. The use of

Table 2. Changes in patient respiration parameters at different time points after LMA-Supreme™ placement

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tidal volume/L</td>
<td>A</td>
<td>0.51 ± 0.34</td>
<td>0.52 ± 0.38</td>
<td>0.50 ± 0.18</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>0.51 ± 0.23</td>
<td>0.51 ± 0.26</td>
<td>0.52 ± 0.13</td>
</tr>
<tr>
<td>Airway pressure/cmH₂O</td>
<td>A</td>
<td>12.78 ± 1.20</td>
<td>12.32 ± 0.89</td>
<td>13.89 ± 1.05</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>13.11 ± 1.27</td>
<td>12.25 ± 0.99</td>
<td>13.78 ± 0.97</td>
</tr>
<tr>
<td>PₖCO₂/cmH₂O</td>
<td>A</td>
<td>35.89 ± 1.27</td>
<td>34.89 ± 1.27</td>
<td>35.90 ± 2.00</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>36.33 ± 1.00</td>
<td>35.33 ± 1.41</td>
<td>36.52 ± 1.88</td>
</tr>
</tbody>
</table>

PₖCO₂: partial pressure of end-tidal carbon dioxide.
Venipuncture following LMA-Supreme™ placement

Table 3. CCA diameter and overlapping between the CCA and right IJV before and after LMA-Supreme™ placement

<table>
<thead>
<tr>
<th>Group</th>
<th>Parameter</th>
<th>Anterior point</th>
<th></th>
<th>Middle point</th>
<th></th>
<th>Posterior point</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Before</td>
<td>After</td>
<td>Before</td>
<td>After</td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>Group A</td>
<td>M l/cm</td>
<td>4.59 ± 0.76</td>
<td>6.47 ± 0.68</td>
<td>0.67 ± 0.08</td>
<td>0.64 ± 0.09</td>
<td>0.70 ± 0.07</td>
<td>0.66 ± 0.08</td>
</tr>
<tr>
<td></td>
<td>N l/cm</td>
<td>6.47 ± 0.68</td>
<td>0.64 ± 0.09</td>
<td>0.70 ± 0.07</td>
<td>0.66 ± 0.08</td>
<td>0.71 ± 0.07</td>
<td>0.69 ± 0.07</td>
</tr>
<tr>
<td></td>
<td>AD d/cm</td>
<td>0.20 ± 0.15</td>
<td>0.44 ± 0.15</td>
<td>0.22 ± 0.21</td>
<td>0.50 ± 0.19</td>
<td>0.32 ± 0.21</td>
<td>0.38 ± 0.20</td>
</tr>
<tr>
<td></td>
<td>A-V l/cm</td>
<td>0.20 ± 0.15</td>
<td>0.44 ± 0.15</td>
<td>0.22 ± 0.21</td>
<td>0.50 ± 0.19</td>
<td>0.32 ± 0.21</td>
<td>0.38 ± 0.20</td>
</tr>
<tr>
<td></td>
<td>OI/%</td>
<td>30 ± 22</td>
<td>70 ± 24</td>
<td>30 ± 29</td>
<td>75 ± 25</td>
<td>43 ± 28</td>
<td>54 ± 26</td>
</tr>
<tr>
<td>Group B</td>
<td>M l/cm</td>
<td>5.00 ± 0.64</td>
<td>7.15 ± 1.59</td>
<td>0.73 ± 0.15</td>
<td>0.68 ± 0.13</td>
<td>0.72 ± 0.12</td>
<td>0.64 ± 0.07</td>
</tr>
<tr>
<td></td>
<td>N l/cm</td>
<td>7.15 ± 1.59</td>
<td>0.73 ± 0.15</td>
<td>0.68 ± 0.13</td>
<td>0.72 ± 0.12</td>
<td>0.64 ± 0.07</td>
<td>0.75 ± 0.13</td>
</tr>
<tr>
<td></td>
<td>AD d/cm</td>
<td>0.12 ± 0.16</td>
<td>0.52 ± 0.07</td>
<td>0.25 ± 0.12</td>
<td>0.61 ± 0.07</td>
<td>0.31 ± 0.17</td>
<td>0.49 ± 0.10</td>
</tr>
<tr>
<td></td>
<td>OI/%</td>
<td>23 ± 17</td>
<td>78 ± 10</td>
<td>37 ± 16</td>
<td>95 ± 5</td>
<td>40 ± 20</td>
<td>75 ± 9</td>
</tr>
</tbody>
</table>

*M*: distance between the midpoint of upper part of thyroid cartilage on the rim and thyroid cartilage at the level of the right CCA; *N*: distance between the upper rim of the thyroid cartilage and the jugular notch (N); *AD*: CCA diameter; *A-V*: overlapping between the right IJV and CCA; *OI*: overlap index; *P < 0.05*, compared with before mask placement; *P < 0.05*, compared with group A.

Table 4. Success rates of IJV puncturing and rates of puncture complications

<table>
<thead>
<tr>
<th>Site</th>
<th>N</th>
<th>Success rates</th>
<th>CCA</th>
<th>hematoma</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1-time</td>
<td>2-times</td>
<td>3-times</td>
</tr>
<tr>
<td>Group A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior</td>
<td>9</td>
<td>1 (11%)</td>
<td>0</td>
<td>1 (10%)</td>
</tr>
<tr>
<td>Middle</td>
<td>10</td>
<td>7 (70%)</td>
<td>8 (80%)</td>
<td>10 (100%)</td>
</tr>
<tr>
<td>Posterior</td>
<td>9</td>
<td>8 (89%)</td>
<td>9 (90%)</td>
<td>9 (90%)</td>
</tr>
<tr>
<td>Group B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior</td>
<td>10</td>
<td>7 (70%)</td>
<td>8 (80%)</td>
<td>10 (100%)</td>
</tr>
<tr>
<td>Middle</td>
<td>10</td>
<td>8 (80%)</td>
<td>9 (90%)</td>
<td>9 (90%)</td>
</tr>
<tr>
<td>Posterior</td>
<td>9</td>
<td>8 (89%)</td>
<td>9 (100%)</td>
<td>9 (100%)</td>
</tr>
</tbody>
</table>

Due to the relative ease of puncturing via the IJV, it is frequently used as a central venous route, particularly when its location has been confirmed using an ultrasound scanner. However, the placement of a LMA changes the IJV diameter and its position relative to the CCA. A high quality ultrasound system used to study the effect of LMA placement on the IJV positioning revealed displacement of the larynx in an anterior direction by the LMA [13]. It was further observed that the presence of a LMA made it difficult to palpitate the carotid artery and perform a subsequent venous cannulation, resulting in increased rate of complications, and even failure in IJV punctures. Difficulties with cannulation may be experienced in the presence of a LMA cuff [13]. Riley et al. [12] recommended for performing a trial LMA deflation to improve the likelihood of a successful venous cannulation, following which an adequate airway can be maintained. However, a non-inflated laryngeal mask might cause para-position with the respiratory tract, and increase the risk of defective ventilation. Another study showed that use of an optimized ultrasound axis in conjunction with a marked introducer needle shortened the time required for IJV catheterization, increased the success rate, and reduced the incidence of mechanical complications [21]. Nevertheless, even while using ultrasound guidance, the placement of a LMA increases the risk of accidentally puncturing.
Venipuncture following LMA-Supreme™ placement

Because the CCA is located posteromedial of the IJV, the chance of a malpuncture in the IJV is generally considered to be low. However, the placement of a LMA relocates the position of the CCA to the back of the IJV, and thus increases overlap between the CCA and IJV. This change has been reported to significantly increase the chances of malpuncture [24]. Our findings showed that placement of either a size 3 or size 4 LMA-Supreme™ greatly increased the degree of overlap between the right IJV and CCA. This result is consistent with a previous report by Takeyama et al. [4]; however, in that study, an LMA-Classic™ size 3 for women and a size 4 for men were used, showing that the positions of the vessels at the lower puncture points were unaffected.

The low puncture point was designated as an area near to where the ramus clavicularis of the sternocleidomastoid muscle attaches to the clavicle. However, if a malpuncture into the CCA were to occur at that point, it will easily cause a hematoma and bleeding that would be difficult to stop by compression. In this study, we examined the positional relationship between the IJV and CCA at the posterior point, which was designated at the lower 1/3 crossing point of the lateral border of the sternocleidomastoid muscle. At the posterior point, there was less overlapping of the IJV and CCA, making it a good puncture site (Figures 2, 3). A puncture performed at this posterior point was accompanied with a lower chance of accidentally puncturing the carotid artery and subsequent complications (e.g., hematoma). As compared with effects of the size 3 LMA-Supreme™, the size 4 LMA-

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**Figure 2.** Ultrasound scans showing the positional relationship between the IJV and CCA before placement of a size 3 LMA-Supreme™.

**Figure 3.** Ultrasound scans showing the positional relationship between the IJV and CCA before placement of a size 4 LMA-Supreme™.
Venipuncture following LMA-Supreme™ placement

Supreme™ had a greater effect on punctures performed at the posterior point (Figures 2, 3). We noticed that overlapping of the IJV and CCA at the middle point after a size 4 mask placement was even greater than that at the anterior point. This could be attributed to the combination of the end level of the cricoid cartilage, because the anatomical positions of the CCA and IJV at the middle point are closer than at the anterior point. Additionally, the posterior point that was located approximately two horizontal fingers above the clavicle was positioned away from the mask air bag, and thus less affected by mask placement. This was consistent with the previous report describing the supraclavicular subclavian vein as a safe and preferable site for CVC [25]. Overlapping of the IJV and CCA remained unchanged after placement of the size 3 LMA-Supreme™. The results of IJV punctures performed at the three points showed that the highest one-time success rate (100%) was achieved when the procedure was made at the posterior point with placement of a size 3 mask. Additionally, there were fewer cases of accidental CCA puncture when using a size 3 mask as compared to a size 4 mask, and this was especially true for punctures performed at the anterior point.

In conclusion, although use of a LMA-Supreme™ may change the positional relationship between the IJV and CCA, a mask of suitable size (size 3 for a patient weighing 50-70 kg) did not significantly increase overlap between the IJV and CCA. When performing IJV puncture without real time ultrasound guidance, the posterior point is the optimal site for avoiding an accidental puncture of the CCA.

Acknowledgements

The research protocol was approved by the Institutional Review Board of the First Hospital of Jilin University (Changchun, China).

Disclosure of conflict of interest

None.

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