Skin vasomotor reflex induced by laryngoscopy: comparison of the McCoy and Macintosh blades

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Summary
We studied 22 female patients (ASA I or II) to investigate if laryngoscopy and intubation induced the skin vasomotor reflex (SVmR), and to compare the effects of the McCoy and Macintosh blades on the SVmR. Anaesthesia was induced with fentanyl, midazolam, vecuronium and nitrous oxide. In 11 patients, the vocal cords were seen for 3 s with the McCoy blade. Two minutes later, laryngoscopy was performed with the Macintosh blade and the trachea was intubated. In the other 11 patients, the first and second laryngoscopies, respectively, were performed with the Macintosh and McCoy blades. Laryngoscopy alone and intubation with laryngoscopy significantly reduced skin blood flow in the ring finger of all patients (P < 0.01), indicating that both procedures provoked the SVmR. The magnitude of the SVmR and haemodynamic changes did not differ significantly between the two groups. (Br. J. Anaesth. 1997; 79: 714–718).

Key words
Anaesthetic technique, laryngoscopy. Larynx, laryngoscopy. Measurement techniques, flowmetry. Skin, blood flow.

Although many investigators have documented a relationship between detrimental circulatory responses and intubation with direct laryngoscopy,1–7 there have been few reports of changes in skin blood flow during these procedures. The recent development of the laser Doppler (LD) flowmeter provides a useful tool for observation of skin vasomotion. LD skin blood flow (LD-SBF) is composed of three components: cardiac, basic and reflex waves.8 The reflex wave that follows an inspiratory gasp or various other somatosensory stimuli manifests as a transient marked reduction in LD-SBF,8–10 and this has been termed the skin vasomotor reflex (SVmR).9 We found recently that various surgical stimuli provoked the SVmR, even under general anaesthesia. As the SVmR is transferred to skin vessels via sympathetic nerves,11–13 it would represent the magnitude of the stress response as a somato-sympathetic reflex when the SVmR is induced by somatosensory stimulation. The main purpose of this study was to investigate if laryngoscopy and intubation induce the SVmR as a stress response.

McCoy, Mirakhur and McCloskey reported that circulatory responses to laryngoscopy were less marked with the use of the McCoy blade compared with the Macintosh blade,14 suggesting that a decreased stress response results from less force being necessary with the McCoy blade during laryngoscopy.15 The second purpose of the study was to compare the McCoy and Macintosh blades regarding the magnitude of the SVmR and the circulatory responses during laryngoscopy and intubation.

Patients and methods
The study was approved by the Institutional Review Board of our hospital, and written informed consent was obtained from all patients. We studied 22 patients undergoing elective gynaecological surgery under general anaesthesia with tracheal intubation. All patients were ASA I or II. Patients were allocated randomly to a McCoy–Macintosh (McC–Mac) (n = 11) or Macintosh–McCoy (Mac–McC) (n = 11) group. Patients with signs of autonomic dysfunction or cardiovascular disease detected by routine clinical laboratory tests and preanaesthetic interview were excluded because the SVmR is suppressed significantly in patients with autonomic neuropathy.9,10,16 No patient was receiving chronic medication, was obese (body mass index more than 26 kg m⁻²) or had an anticipatory difficult airway.

Atropine 0.5 mg i.m. and either hydroxyzine 1 mg kg⁻¹ or midazolam 0.08 mg kg⁻¹ were administered to patients 30 min before they entered the operating room. In the operating room, the lead CM5 electrocardiogram (ECG) and pulse oximeter were monitored using a Datex AS/3 anaesthesia monitor (Helsinki, Finland). Heart rate (HR) was measured by the moving average method, which used 4 beats if HR was less than 99 beat min⁻¹ and 8 beats if HR was equal to or more than 100 beat min⁻¹. Tonometric arterial pressure (TAP), which has been reported to have an excellent correlation with invasive arterial pressure,17 was measured by the...
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Nippon Colin BP-508-type S tonometer (Komaki, Japan). The tonometer sensor was attached to the left wrist over the radial artery and calibrated at intervals of 2.5 min by an oscillometric cuff attached to the right upper arm. Arterial pressure was monitored continuously and recorded by a heat pen recorder. Ambient temperature was maintained at 25–26 °C.

An i.v. cannula was inserted into the median antecubital vein of the right arm for infusion of Ringer’s lactate solution and drug administration. General anaesthesia was induced with fentanyl 3 μg kg⁻¹ i.v. and midazolam 0.1 mg kg⁻¹ i.v. After loss of consciousness, vecuronium 0.1 mg kg⁻¹ was administered. Subsequently the patient’s lungs were ventilated via a face mask with 50% nitrous oxide in oxygen through a semi-closed anaesthesia system. End-tidal concentrations of carbon dioxide and nitrous oxide, obtained from the Y-piece of the anaesthesia system, were monitored by the AS/3 system. Neuromuscular block was monitored by transcutaneous electrical stimulation of the right ulnar nerve (Innervator, Fisher and Paykel, Auckland, New Zealand).

In the McC–Mac group, laryngoscopy was performed with the McCoy blade (size 3) after complete neuromuscular block was achieved (laryngoscopy-1). The standard manner, including “levering”¹⁸ of the McCoy blade, was used. After a clear view of the vocal cords was obtained (grade I view defined by Cormack and Lehane) for 3 s, laryngoscopy was discontinued. The patient’s lungs were ventilated again via the face mask with 50% nitrous oxide in oxygen for 2 min. Laryngoscopy was then performed with the Macintosh blade (size 3) and the trachea was intubated immediately (intubation with laryngoscopy-2). In the Mac–McC group, the same procedures were performed but the laryngoscopies were performed with the Macintosh and McCoy blades, respectively. We changed the blade with each laryngoscopy to reduce the bias of the anaesthetist concerning the blades. One of two trained anaesthetists who were familiar with each blade was allocated randomly to the groups. They were blinded to the results of skin blood flow (described later) and changes in arterial pressure and heart rate.

MONITORING LASER DOPPLER SKIN BLOOD FLOW (LD-SBF)

For monitoring LD-SBF we used an LD flowmeter (ALF 2100, Advance, Tokyo). A plate-type probe can influence vasomotion.¹⁰⁻¹⁹ Therefore, before induction of anaesthesia, the SVmR was tested by an inspiratory gasp to detect any subclinical vasomotor disorder or probe factor.⁸⁻¹⁰ Patients lacking the SVmR were excluded from further study. After induction of anaesthesia, a marked reduction in the LD-SBF following each procedure was recognized as the SVmR (fig. 1).⁸⁻¹⁰ The LD-SBF wave recorded on a heat pen recorder was scanned by a ScanJet IIc software (Hewlett Packard, Palo Alto, CA, USA) and saved in the TIFF format. Analysis of the magnitude of the SVmR was performed on a Power Macintosh 8500/120 computer (Apple, Cupertino, CA, USA) using the public domain NIH image program (developed at the US National Institutes of Health and available from the Internet by anonymous FTP from zippy.nimh.nih.gov or on floppy disk from the National Technical Information Service, Springfield, VA, part number PB95–500195GEI). We used two indices to quantitatively evaluate the magnitude of the SVmR. The reduction ratio in the SVmR (SVmR-RR) was calculated using the following equation (fig. 1)⁸⁻¹⁰;

\[
SVmR-RR = 1 - \frac{b}{a}
\]

where \(a = \text{LD-SBF immediately before laryngoscopy}\) and \(b = \text{minimal LD-SBF during laryngoscopy or tracheal intubation}\). The area over the LD-SBF wave and under a tangent line drawn between the drop point and recovery point was measured as SVmR area.

DATA ANALYSIS

Mean arterial pressure (MAP) was calculated as diastolic arterial pressure and one-third pulse pressure. The change in MAP was measured as the difference between MAP recorded before laryngoscopy-1 and maximum MAP in the period during laryngoscopy-1 to 2 min after this. In a similar manner, the change in MAP during intubation with laryngoscopy-2 was calculated using the arterial pressure value from before laryngoscopy-2 to 2 min after intubation. The change in HR in laryngoscopy-1 was determined as the difference between HR recorded before laryngoscopy-1 and maximum
HR during laryngoscopy-1 to 2 min after this. The change in HR in intubation with laryngoscopy-2 was calculated similarly.

Results are presented as mean (SD). Haemodynamic data within each group were analysed using a repeated measures analysis of variance, and differences between groups were analysed using the Student’s t test. Changes in LD-SBF, SVMR-RR and SVMR area were assessed by the Wilcoxon signed rank test within each group, and the Mann–Whitney U test between groups. P<0.05 was considered significant.

Results

An inspiratory gasp provoked the SVMR in all patients before induction of anaesthesia; therefore, none was excluded. Patient age, weight and body mass index in the McC–Mac group were 34.2 (range 21–47) yr, 54.9 (so 10.3) kg and 22.3 (2.7), respectively. Those in the Mac–McC group were 34.5 (26–50) yr, 55.3 (6.9) kg and 22.9 (2.6). There were no significant differences between the groups in patient characteristics. No patient had a difficult airway. A clear view of the vocal cords (grade I view defined by Cormack and Lehane) was obtained with both the Macintosh and McCoy blades in each patient.

Figure 2 shows simultaneous recording of tonometry arterial pressure (TAP) and LD-SBF level of representative patients from the McC–Mac group (top) and the Mac–McC group (bottom). Table 1 lists the changes in LD-SBF level. The LD-SBF level increased after induction of anaesthesia in both groups. Laryngoscopy-1 and intubation with laryngoscopy-2 procedures significantly reduced the LD-SBF level in both groups (P<0.01). The LD-SBF level at 1 min after each procedure recovered to the level observed immediately before the procedure. There were no significant differences between the groups regarding changes in LD-SBF level.

MAGNITUDE OF THE SVMR AND HAEMODYNAMIC RESPONSES

There were no significant differences in SVMR-RR between the two groups (table 2). In each group, the SVMR-RR of laryngoscopy-1 also did not differ from that of intubation with laryngoscopy-2. There was no significant difference between the groups in

<table>
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<tr>
<th>Table 1</th>
<th>Mean (SD) changes in laser-Doppler skin blood flow (LD-SBF) (ml 100 g⁻¹ min⁻¹). n=11 patients in each group. **P&lt;0.01 compared with previous time point within a group</th>
</tr>
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<tbody>
<tr>
<td>McCoy–Macintosh</td>
<td>Macintosh–McCoy</td>
</tr>
<tr>
<td>Baseline</td>
<td>15.1 (11.6)</td>
</tr>
<tr>
<td>Before laryngoscopy-1</td>
<td>38.2 (10.9)**</td>
</tr>
<tr>
<td>Minimum during laryngoscopy-1</td>
<td>17.2 (11.2)**</td>
</tr>
<tr>
<td>Before laryngoscopy-2</td>
<td>36.1 (9.3)**</td>
</tr>
<tr>
<td>Minimum during intubation</td>
<td>11.0 (9.8)**</td>
</tr>
<tr>
<td>1 min after intubation</td>
<td>38.9 (11.2)**</td>
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<th>Table 2</th>
<th>Changes in skin vasomotor reflex (SVmR) and haemodynamic data (mean SD)). n=11 patients in each group. SVmR-RR= reduction ratio of skin vasomotor reflex. *P&lt;0.05, **P&lt;0.01, laryngoscopy alone vs laryngoscopy and intubation within a group</th>
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<tr>
<td>McCoy–Macintosh</td>
<td>Macintosh–McCoy</td>
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<tr>
<td>Laryngoscopy-1</td>
<td>Intubation with laryngoscopy-2</td>
</tr>
<tr>
<td>SVmR-RR</td>
<td>0.57 (0.20)</td>
</tr>
<tr>
<td>SVmR area (pixel)</td>
<td>450 (276)</td>
</tr>
<tr>
<td>Changes in HR (beat min⁻¹)</td>
<td>0.9 (3.4)</td>
</tr>
<tr>
<td>Changes in MAP (mm Hg)</td>
<td>7.4 (7.3)</td>
</tr>
</tbody>
</table>
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SVmR area; however, SVmR area in intubation with laryngoscopy-2 was significantly greater than that in laryngoscopy-1 within each group (P = 0.01 in the McC–Mac group; P = 0.005 in the Mac–McC group). HR and MAP did not change during laryngoscopy-1, whereas intubation with laryngoscopy-2 significantly increased both HR (P = 0.006 in the McC–Mac group; P = 0.008 in the Mac–McC group) and MAP (P = 0.04 in the McC–Mac group; P = 0.03 in the Mac–McC group). However, haemodynamic changes were not significantly different between groups.

Discussion

We have demonstrated that both laryngoscopy and intubation provoked the skin vasomotor reflex (SVmR), nociceptive stimulation by intubation with laryngoscopy had a larger magnitude than that by laryngoscopy alone and the magnitude of nociception caused by laryngoscopy, which was measured by the SVmR, did not differ whether the Macintosh or McCoy blade was used.

The SVmR involves complex mechanisms, that is afferent, central and efferent pathways. An inspiratory gasp and various sensory stimuli are representative afferent inputs for the SVmR. During laryngoscopy and intubation, nociceptive signals are generated by elevation of the epiglottis with the laryngoscope and by insertion of the tube into the trachea. The signals are conducted to the brain through the glossopharyngeal nerve and the vagus. The central polysynaptic pathways of the SVmR have not yet been clarified. The pressor response to laryngoscopy and intubation is mediated via sympathetic nerves. The efferent pathway of the SVmR caused by any afferent stimulus has also been reported to be composed of sympathetic nerve fibres.

The anaesthesia techniques among the studies of circulatory responses to laryngoscopy and intubation have varied widely. As changes in HR and MAP in our study did not differ markedly from the haemodynamic changes in non-treated groups in previous reports, our anaesthetic technique was adequate for tracheal intubation. We found recently that laryngoscopy and intubation provoked the SVmR during induction of anaesthesia with both nitrous oxide–sevoflurane and fentanyl–propofol (unpublished observation). Sympathetic vasomotor activity may exert potent control of vascular resistance in the skin and skin tissues which serve as potentially major targets for powerful sympathetic homeostatic reflexes.

Sympathetic discharge patterns recorded simultaneously from different skin nerves show striking similarities. Our findings suggest that the SVmR contributes, at least in part, to the haemodynamic responses during laryngoscopy and intubation. There are few reports of the SVmR during general anaesthesia. Further studies are necessary to clarify if there is an intimate relationship between the SVmR and haemodynamic responses during laryngoscopy and intubation.

The SVmR is an indirect method of assessment of the sympathetically mediated reflex. It has not yet been confirmed if a linear, quantitative correlation exists between the magnitude of the SVmR and skin sympathetic nerve activity. However, the relationship between the SVmR-RR induced by transcutaneous electrical stimulation of the ulnar nerve and the current intensity of the stimulus showed a significant correlation during nitrous oxide–sevoflurane anaesthesia (unpublished observation). Evaluation of the SVmR may have the potential to be a non-invasive indicator of nociception during general anaesthesia.

We found that combined laryngoscopy and intubation provided larger nociceptive stimulation compared with laryngoscopy alone. The durations of the two procedures should not account for the difference because the elimination half-lives of fentanyl and midazolam are reported to be 3.6 h and 3.8 h respectively. Stoelting reported that prolonged laryngoscopy increased mean arterial pressure with time during the first 45 s. This report and our findings suggest that the duration of nociceptive stimulation itself plays an important role in the magnitude of SVmR area and haemodynamic changes during laryngoscopy and intubation.

McCoy and colleagues demonstrated that the circulatory responses to laryngoscopy were less marked with the McCoy blade compared with the Macintosh blade. In our study there were no significant differences in the magnitude of the SVmR and haemodynamic changes induced by the use of either blade. To expose the larynx, the tip of the blade is inserted into the epiglottic vallecula and moved up towards the mandible. These procedures are common to each blade. Regardless of the blade style, a 3-s view of the larynx caused the SVmR. Cook and Turky reported that the McCoy blade in the neutral position provided a poorer view of the larynx and needed “levering” to obtain the view similar to that provided by the Macintosh blade. This report and our findings suggest that the magnitude of nociception caused by elevation of the epiglottis itself does not differ between the two blades for patients with a normal body size and anatomical structure of the upper airway.

References


