Airway Management in Reconstructive Surgery for Noma (Cancrum Oris)

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Written consents have been obtained from all patients whose images appear in this manuscript.

The authors declare no conflicts of interest.

Authors’ note: The images of patients with noma show considerable disfiguration. At the request of the editor, these images are not included in the published paper, but are only available online. We would encourage readers to access these images, as we believe they are central to an understanding of the disease process and the challenges involved in airway management. Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal’s Web site (www.anesthesia-analgesia.org).

Reprints will not be available from the authors.

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Noma (cancrum oris) is a disease of poverty and malnutrition, which predominantly affects children younger than 10 years in developing countries. Although the majority of sufferers die of sepsis at the time of the initial infection, or of subsequent starvation due to severe trismus and an inability to eat, a small minority of patients survive and require reconstructive surgery for severe facial scarring and deformity. These patients present significant problems to the anaesthesiologist with regard to airway management. We present a series of 26 patients undergoing primary and subsequent reconstructive surgery, with particular focus on airway management. We show that airway management, while challenging, can be performed safely and successfully by using individualized airway plans but may require advanced techniques and equipment.

Traditional tests focusing on the anterior/superior airway are helpful in assessing patients with facial deformity due to noma. (Anesth Analg 2013;117:210–217)

Noma is an opportunistic infection of facial tissues by normal oral commensal organisms. Fusobacterium nucleatum, Fusobacterium necrophorum, and Borrella vincentii have been implicated. The possible complex microbiological etiologies are discussed in the excellent review article by Enwonwu et al. and are beyond the scope of this paper, but it is interesting to note that isolation of the causative organism is hindered because secondary infection is universally quick in onset and extensive. The infection causes rapidly spreading necrotizing gangrene with massive tissue loss.

Multiple factors contribute to susceptibility to the disease. Chronic, severe malnutrition is a prerequisite. Noma is not reported in well-nourished African children, and noma only returned to Europe with the starvation experienced by inmates of the concentration camps. Adelsberger describes an outbreak in 1943 among children in Birkenau. Noma only develops when the immune system has been sufficiently weakened to render the subject susceptible to infection. It has been recognized for centuries that infection often occurs after a severe systemic illness like measles or malaria. Noma has been reported in patients in association with human immunodeficiency virus infection. The susceptible patient’s oral bacterial count is usually high, and noma usually requires minor trauma to break the mucosal barrier. Death usually occurs within 2 weeks due to sepsis.

ACUTE NOMA

Most authorities agree that the disease usually starts from the oral cavity and spreads outwards. The lesion begins with a small ulcer on the alveolar margin or the buccal membrane. This breach of the mucosal barrier allows the ingress of bacteria, which spread rapidly in the tissues of the face, causing extensive, painful swelling. Necrosis and ulceration follow, and infection often spreads to adjacent bone. Often teeth are exfoliated. Massive bone destruction can occur. The subsequent sequestra can involve the mandible, maxilla, orbital floor, or all 3. Over the following days, the lesion becomes necrotic with massive tissue loss. Secondary infection is inevitable. The tissue loss is always
greater internally than is evident on external appearance. The tissue loss can involve any part of the face and may be unilateral, central, or bilateral. Most patients rapidly die if untreated. With bilateral involvement, death is inevitable. The few survivors must cope with profound functional and cosmetic problems associated with healed noma.

LATER SEQUELAE OF NOMA
The long-term anatomical sequelae of noma are highly variable, and therefore, the airway challenges to the anesthesiologist differ greatly from one patient to another. The extent of the defect depends on the anatomical site of the primary lesion and the stage of development of the facial skeleton at the time of infection. One of the common consequences of noma of particular concern to the anesthesiologist is absolute trismus. This is due to the formation of an extraarticular ankylosis bridging the gap between the mandible and maxilla (Fig. 1, A and B), consisting of dense fibrous tissue, or in some cases, bone. Commonly, the coronoid processes are grossly hypertrophied and contribute to the ankylosis. Anecdotally, ankylosis is said to occur when the initial infection extends posterior to the first molar, although there is a lack of data to support this assertion. The trismus is permanent and severe, with surgical release the only therapeutic option, although unfortunately recurrence is common. The trismus compounds the environmental causes of malnutrition, because sufferers may have to eat by mashing food and pushing it through the retro-molar gap or gaps left by exfoliated teeth or the loss of facial tissue as a result of noma itself. Reconstructive surgery is the only option for improving functional and cosmetic outcome.

AIRWAY MANAGEMENT
A number of strategies have been suggested to aid negotiation of the airway in noma patients. There are case reports describing transtracheal jet ventilation, awake tracheostomy under ketamine anesthesia, blind nasal intubation proceeding to emergency cutting of the bony ankylosis followed by oral intubation and minitracheostomy in cases of failure and asleep direct laryngoscopy and intubation followed by submental intubation. There is a small case series detailing 4 children having asleep fiberoptic intubation (FOI) under ketamine and halothane anesthesia.

Given the relative paucity of reports detailing airway management or airway assessment in patients with healed noma, the aim of this paper is to detail the authors’ experience of anesthetizing a relatively large case series of noma patients for reconstructive surgery, with particular focus on airway management.

METHODS
In a 2-week period in January 2012, during a mission run by Facing Africa in Addis Ababa, Ethiopia, we anesthetized 26 noma survivors for facial reconstruction surgery. The airway challenges in these patients were significant. We developed a strict procedure for airway assessment and airway management planning which we adhered to with each patient. Each patient had a full airway assessment, usually performed the evening before surgery. Two consultant anesthesiologists working together undertook this assessment, and a number of measurements and scores relating to the airway were collected (Table 1).

Our airway assessment included a review of the notes as a number of our patients were returning for second or third stage surgery and had anesthetic charts available from previous operations. However, the airway changes as a result of corrective surgery can be profound and may necessitate different airway management strategies from one anesthetic to the next, reducing the utility of notes from previous anesthetics in current airway planning.

Imaging
Some patients had computed tomography scans of the head and neck performed as part of the surgical planning process, and if available, these were reviewed. Imaging consistently showed normal posterior and inferior airway structures, even in the presence of extensive anterior airway deformation.

After a clinical evaluation of the airway, the 2 anesthesiologists formed a sequential airway management strategy, broadly following Difficult Airway Society (DAS) guidelines. The intended airway management was denoted plan A, and a secondary management plan was denoted plan B. Plan C was primarily an “oxygenation” strategy, and plan D

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**Figure 1.** (A) Three-dimensional reconstruction of cranial computed tomography showing bony ankylosis (arrow). (B) Contralateral side shown for comparison. (C) External appearance, online image only (see Supplemental Digital Content 1, http://links.lww.com/AA/A538).
involved either percutaneous or surgical access to the trachea to deal with a “cannot intubate, cannot ventilate” scenario.

**Equipment**

We had a reasonable range of airway management equipment available to us (Table 2), but rather less choice of equipment than is available to us in our everyday Western practice. Thus, our airway management plans need to be viewed as “context-sensitive.”

All the cases were performed in January 2012 by the authors, assisted by a British operating department practitioner, who was part of mission team, and a number of Ethiopian anesthetic nurses under training. The anesthetic nurses performed some of the easier intubations under strict supervision.

After induction of anesthesia and once the patient’s airway was secured, we recorded how easy the patients’ lungs were to hand ventilate (using the Han scale), and ease of placement of the tracheal tube or supraglottic airway device. We noted whether we had adhered to or deviated from our preoperative airway strategy, and which of our airway management plans (A, B, C, or D) we ultimately needed to use. We noted any airway complications that occurred.

**RESULTS**

**Patient Characteristics**

**Gender and Age**

Fifteen of our 26 patients were female. The majority of patients operated on were adolescents and young adults (range 8–62 years of age, mean 26.5 years of age). This reflects the pathological and sociological history of the condition.

**Table 1. Airway Assessment**

<table>
<thead>
<tr>
<th>Demographics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, gender, height, weight, (body mass index was calculated).</td>
<td></td>
</tr>
<tr>
<td>Thyromental distance (Patil test)</td>
<td>The distance from the tip of thyroid cartilage to the tip of mandible, neck fully extended (cm).</td>
</tr>
<tr>
<td>Sternomental distance (Sawwa test)</td>
<td>The distance from the sternal notch to the tip of mandible, neck fully extended and the mouth closed (cm).</td>
</tr>
<tr>
<td>Mallampati score (with Samsoon and Young’s modification)</td>
<td>Based on structure visualized with maximal tongue protrusion in the sitting position.</td>
</tr>
<tr>
<td>Class I—soft palate, fauces, uvula, pillars</td>
<td></td>
</tr>
<tr>
<td>Class II—soft palate, fauces, portion of uvula</td>
<td></td>
</tr>
<tr>
<td>Class III—soft palate, base of uvula</td>
<td></td>
</tr>
<tr>
<td>Class IV—hard palate only</td>
<td></td>
</tr>
<tr>
<td>Interincisor gap</td>
<td>The distance between the incisors (or alveolar margins) with the mouth open maximally (cm).</td>
</tr>
<tr>
<td>Extent of jaw protrusion</td>
<td></td>
</tr>
<tr>
<td>Class A—able to protrude the lower incisors anterior to the upper incisors.</td>
<td></td>
</tr>
<tr>
<td>Class B—lower incisors can protrude to, but not anterior to the upper incisors.</td>
<td></td>
</tr>
<tr>
<td>Class C—lower incisors cannot protrude to the upper incisors.</td>
<td></td>
</tr>
<tr>
<td>Neck extension</td>
<td></td>
</tr>
<tr>
<td>Assessed by:</td>
<td>Placing 1 finger on the patient’s chin and 1 finger on the occipital protuberance and extending the head maximally on the cervical spine. At full extension, if the chin remained lower than the level of the occipital protuberance, we considered extension to be limited.</td>
</tr>
</tbody>
</table>

**Table 2. Available Airway Equipment**

| Macintosh 2 and 3 blades (GE Healthcare, Chalfont St Giles, UK) | 4.1 mm Fiberoptic bronchoscope (Aizu Olympus Co. Ltd, Fukushima Japan) |
| Glidescope (blades 1, 2, 2.5, 3, 4—Verathon Inc., Bothell, WA) | Laryseal laryngeal mask airway (Flexicare Medical Ltd, Mountain Ash, Mid Glamorgan, UK) |
| Laryseal laryngeal mask airway (Intavent Direct, OLD Amersham, UK) | ProSeal laryngeal mask airway (Intavent Direct, Old Amersham, UK) |
| Gum elastic bougie (Portex, Smiths Medical, St Paul, MN) | Antree intubation catheter (Cook Medical, Bloomington, IN) |
| Miles™ 15 mm connector—Portex, Smiths Medical | Mini-trach II kit (4.0 15 mm connector—Portex, Smiths Medical) |
| Patil Emergency Cricothyrotomy Catheter Set (Cook Medical) | Glidescope (blades 1, 2, 2.5, 3, 4—Verathon Inc., Bothell, WA) |
| VBM jet ventilation catheter (VBM, Sulz, Germany) |        |

Benjamin et al. 2012

**Height, Weight, and Body Mass Index**

As might be expected from the pathogenesis of the condition, there was no obesity in our group of patients. All our patients were thin or underweight as defined by their body mass index (BMI), with BMIs universally <21.9. Sixteen of 26 patients had BMIs <18.5. The lowest BMI in our patients was 14.

**Airway Management**

Of the patients who did not undergo awake FOI, none was difficult to mask ventilate as indicated by their Han mask ventilation scores of 1 and 2. Only 3 patients required the insertion of oropharyngeal airways to aid mask ventilation.

Our primary intubation plan (plan A) was to use the Glidescope in 14 of 26 cases, asleep FOI in 4 of 26 cases, awake FOI in 4 of 26 cases, and direct laryngoscopy in 3 cases. In 1 case, we used only ketamine sedation for tooth extraction. In all the cases where plan A was the use of the Glidescope, our secondary intubation plan (plan B) was asleep FOI.

In the majority of cases (23/26), our initial plan A was successful. On 2 occasions, we progressed to plan B. On 1 occasion we deviated from our predetermined plans completely. We did not need to progress to plan C or D on any occasion. The 2 cases where we moved on from plan A are described below, and the airway measurements and airway plans for those patients are recorded in Table 3.

Patient 9 undergoing Abbe-Estlander flap construction, tooth extraction, submental flap, and turnover for lower lip reconstruction proved to be an unexpectedly difficult Glidescope intubation. Although the video laryngoscopy gave a video view akin to a Cormack and Lehane grade 1 laryngoscopy, passing the nasal tube proved impossible as a result of an unexpectedly anterior larynx. Plan B (asleep FOI) was successful.

Patient 13 undergoing commissuroplasty ± sulcoplasty and suspension had previously undergone reconstructive surgery. On the basis of our preoperative assessment, we predicted that direct laryngoscopy would be impossible, with a Mallampati score of 4, interincisor distance of 1 cm, and poor jaw protrusion. A nasal intubation was required for surgical reasons. Use of the Glidescope allowed good laryngeal visualization (video grade 2 laryngoscopy), but
**Table 3. Patient Demographics, Airway Measurements and Airway Plans, Including Airway Technique Ultimately Used**

<table>
<thead>
<tr>
<th>Patient no.</th>
<th>Sex</th>
<th>Age (y)</th>
<th>BMI</th>
<th>Surgery</th>
<th>Mallampati core</th>
<th>Thyromental distance (cm)</th>
<th>Sternomental distance (cm)</th>
<th>Interincisor gap (cm)</th>
<th>Grade of jaw protrusion</th>
<th>Neck movement</th>
<th>Plan A</th>
<th>Plan B</th>
<th>Plan C</th>
<th>Plan D</th>
<th>Final plan used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>20</td>
<td>17</td>
<td>Mobilization lower lip, turnover flap</td>
<td>2</td>
<td>10</td>
<td>20</td>
<td>4</td>
<td>C</td>
<td>Normal</td>
<td>Glidescope</td>
<td>Asleep FOI</td>
<td>LMA</td>
<td>FON</td>
<td>A</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>18</td>
<td>16</td>
<td>Abbe-Estlander local flap</td>
<td>1</td>
<td>7</td>
<td>15</td>
<td>4</td>
<td>B</td>
<td>Normal</td>
<td>Glidescope</td>
<td>asleep FOI</td>
<td>LMA</td>
<td>FON</td>
<td>A</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>8</td>
<td>14</td>
<td>Ankylosis release</td>
<td>4</td>
<td>7</td>
<td>13</td>
<td>0</td>
<td>C</td>
<td>Normal</td>
<td>asleep FOI</td>
<td>FON</td>
<td>—</td>
<td>—</td>
<td>A</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>35</td>
<td>20</td>
<td>Removal of teeth ± radial forearm free flap</td>
<td>1</td>
<td>9</td>
<td>15</td>
<td>3</td>
<td>C</td>
<td>Normal</td>
<td>Glidescope</td>
<td>Asleep FOI</td>
<td>LMA</td>
<td>FON</td>
<td>A</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>17</td>
<td>16</td>
<td>Rib cartilage and conchal bowl graft to nose reconstruction</td>
<td>2</td>
<td>8</td>
<td>16</td>
<td>2.5</td>
<td>A (no lower incisors)</td>
<td>Normal</td>
<td>Direct laryngoscopy</td>
<td>Glidescope</td>
<td>LMA/HV</td>
<td>FON</td>
<td>A</td>
</tr>
<tr>
<td>6</td>
<td>F</td>
<td>17</td>
<td>17</td>
<td>Radial forearm free flap, Ankylosis release</td>
<td>4</td>
<td>8</td>
<td>18</td>
<td>0</td>
<td>C</td>
<td>Normal</td>
<td>Awake FOI</td>
<td>Asleep FOI</td>
<td>FON</td>
<td>—</td>
<td>A</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>41</td>
<td>19</td>
<td>McGregor flap, Total lower lip reconstruction</td>
<td>1</td>
<td>8</td>
<td>14</td>
<td>6</td>
<td>C</td>
<td>Normal</td>
<td>Glidescope</td>
<td>Asleep FOI</td>
<td>FON</td>
<td>—</td>
<td>A</td>
</tr>
<tr>
<td>8</td>
<td>M</td>
<td>30</td>
<td>14</td>
<td>Ankylosis release + radial forearm free flap</td>
<td>4</td>
<td>12</td>
<td>21</td>
<td>−0.5</td>
<td>C</td>
<td>Normal</td>
<td>Awake FOI</td>
<td>Asleep FOI</td>
<td>FON</td>
<td>—</td>
<td>A</td>
</tr>
<tr>
<td>9</td>
<td>F</td>
<td>55</td>
<td>20</td>
<td>Tooth removal, Abbe-Estlander, Turnover of scar + submental flap</td>
<td>1</td>
<td>6</td>
<td>14</td>
<td>4</td>
<td>C</td>
<td>Normal</td>
<td>Glidescope</td>
<td>Asleep FOI</td>
<td>LMA/HV</td>
<td>FON</td>
<td>B</td>
</tr>
<tr>
<td>10</td>
<td>F</td>
<td>16</td>
<td>20</td>
<td>Radial forearm free flap (with nasal construct) to face</td>
<td>3</td>
<td>7</td>
<td>12</td>
<td>3.5</td>
<td>A</td>
<td>Normal</td>
<td>Glidescope</td>
<td>Asleep FOI</td>
<td>FON</td>
<td>—</td>
<td>A</td>
</tr>
<tr>
<td>11</td>
<td>F</td>
<td>29</td>
<td>16</td>
<td>Removal of teeth. Turnover flap. Advance lower lip, Submental flap</td>
<td>2</td>
<td>5.5</td>
<td>12</td>
<td>3</td>
<td>A</td>
<td>Normal</td>
<td>Glidescope</td>
<td>Asleep FOI</td>
<td>LMA</td>
<td>FON</td>
<td>A</td>
</tr>
<tr>
<td>12</td>
<td>M</td>
<td>26</td>
<td>18</td>
<td>Abbe-Estlander + submental flap</td>
<td>1</td>
<td>11</td>
<td>18</td>
<td>2</td>
<td>B</td>
<td>Normal</td>
<td>Glidescope</td>
<td>Asleep FOI</td>
<td>LMA</td>
<td>FON</td>
<td>A</td>
</tr>
<tr>
<td>13</td>
<td>F</td>
<td>18</td>
<td>17</td>
<td>Commissuroplasty and thinning of flap</td>
<td>4</td>
<td>7</td>
<td>13</td>
<td>1</td>
<td>C</td>
<td>Normal</td>
<td>Glidescope</td>
<td>Asleep FOI</td>
<td>LMA</td>
<td>FON</td>
<td>B</td>
</tr>
<tr>
<td>14</td>
<td>F</td>
<td>20</td>
<td>19</td>
<td>Dermofat graft to right upper lip</td>
<td>1</td>
<td>8</td>
<td>15</td>
<td>5</td>
<td>A</td>
<td>Normal</td>
<td>Direct laryngoscopy</td>
<td>Glidescope</td>
<td>LMA</td>
<td>FON</td>
<td>A</td>
</tr>
<tr>
<td>15</td>
<td>M</td>
<td>40</td>
<td>17</td>
<td>Total nose reconstruction with forehead flap + rib graft.</td>
<td>1</td>
<td>7</td>
<td>15</td>
<td>5</td>
<td>C</td>
<td>Normal</td>
<td>Glidescope</td>
<td>Asleep FOI</td>
<td>LMA/HV</td>
<td>FON</td>
<td>A</td>
</tr>
</tbody>
</table>

(Continued)
### Table 3. (Continued)

<table>
<thead>
<tr>
<th>Patient no.</th>
<th>Sex</th>
<th>Age (y)</th>
<th>BMI</th>
<th>Surgery</th>
<th>Mallampati core</th>
<th>Thyromental distance (cm)</th>
<th>Sternoternal distance (cm)</th>
<th>Interincisor gap (cm)</th>
<th>Grade of jaw protrusion</th>
<th>Neck movement</th>
<th>Plan A</th>
<th>Plan B</th>
<th>Plan C</th>
<th>Plan D</th>
<th>Final plan used</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>F</td>
<td>20</td>
<td>18</td>
<td>Bilateral costochondral graft + ankylosis release + genioplasty</td>
<td>4</td>
<td>6</td>
<td>14</td>
<td>−0.5</td>
<td>C</td>
<td>Normal awake FOI</td>
<td>asleep FOI</td>
<td>HV</td>
<td>FON</td>
<td>—</td>
<td>A</td>
</tr>
<tr>
<td>17</td>
<td>F</td>
<td>15</td>
<td>17</td>
<td>Radial forearm free flap with ankylosis release</td>
<td>4</td>
<td>5</td>
<td>13</td>
<td>1</td>
<td>C</td>
<td>Normal asleep FOI</td>
<td>FON</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>A</td>
</tr>
<tr>
<td>18</td>
<td>M</td>
<td>20</td>
<td>16</td>
<td>Steeple flap. Total lower lip reconstruction</td>
<td>1</td>
<td>7</td>
<td>17</td>
<td>4.5</td>
<td>A</td>
<td>Normal Glidescope</td>
<td>Asleep FOI</td>
<td>LMA</td>
<td>FON</td>
<td>Deviated from plans</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>M</td>
<td>17</td>
<td>16</td>
<td>Rib graft reconstruction left cheek + commissuroplasty + scar revision</td>
<td>3</td>
<td>8.5</td>
<td>22</td>
<td>0.5</td>
<td>A (fixed protruded)</td>
<td>Normal awake FOI</td>
<td>FON</td>
<td>—</td>
<td>—</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>F</td>
<td>48</td>
<td>17</td>
<td>Abbe-Estlander + turnover flap + submental flap</td>
<td>2</td>
<td>8</td>
<td>10</td>
<td>4</td>
<td>B</td>
<td>Normal Glidescope</td>
<td>Asleep FOI</td>
<td>HV</td>
<td>FON</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>F</td>
<td>35</td>
<td>18</td>
<td>Lip closure</td>
<td>1</td>
<td>5.5</td>
<td>15</td>
<td>5.5</td>
<td>B</td>
<td>Normal Asleep FOI</td>
<td>LMA</td>
<td>HV</td>
<td>FON</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>M</td>
<td>62</td>
<td>19</td>
<td>Removal of offending teeth</td>
<td>2</td>
<td>7</td>
<td>18</td>
<td>2</td>
<td>C</td>
<td>Normal Ketamine sedation</td>
<td>LMA</td>
<td>—</td>
<td>—</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>M</td>
<td>32</td>
<td>19</td>
<td>Radial forearm free flap + labiaplasty</td>
<td>1</td>
<td>8</td>
<td>17</td>
<td>3</td>
<td>C</td>
<td>Normal Glidescope</td>
<td>Asleep FOI</td>
<td>HV</td>
<td>FON</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>M</td>
<td>11</td>
<td>16</td>
<td>Ankylosis release, local flap to buccal mucosa</td>
<td>4</td>
<td>6</td>
<td>12</td>
<td>−0.5</td>
<td>C</td>
<td>Normal Asleep FOI</td>
<td>FON</td>
<td>—</td>
<td>—</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>F</td>
<td>unknown</td>
<td></td>
<td>Nasal reconstruction</td>
<td>1</td>
<td>6.5</td>
<td>18</td>
<td>4.5</td>
<td>A</td>
<td>Normal Direct laryngoscopy</td>
<td>LMA</td>
<td>HV</td>
<td>FON</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>F</td>
<td>18</td>
<td>21</td>
<td>Debubking and resuspension of previous free flap right cheek</td>
<td>4</td>
<td>7</td>
<td>17</td>
<td>2</td>
<td>B</td>
<td>Normal Glidescope</td>
<td>Asleep FOI</td>
<td>LMA</td>
<td>FON</td>
<td>A</td>
<td></td>
</tr>
</tbody>
</table>

FON = *front of neck* access; HV = hand ventilation; LMA = laryngeal mask airway; FOI = fiberoptic intubation.
again, an anterior larynx and restricted intraoral space prevented tube placement. Asleep FOI was successful.

On 1 occasion, we deviated from our original airway management plan. This occurred in a patient 18, who was to undergo steeple flap and lower lip reconstruction. We had not predicted difficulties from assessment of her airway. Two consultant anesthesiologists were present. For surgical reasons, a nasal tube was required. The initial attempt at asleep FOI failed as a result of bleeding from the nose. We inserted a Glidescope and gained an acceptable laryngeal view but were unable to insert the tracheal tube because of an anterior lying larynx. These advanced techniques were abandoned and direct laryngoscopy gave a Cormack and Lehane grade 2 view and the nasal tube was placed with the assistance of Magill forceps. Between attempts at intubation, with the use of an oropharyngeal airway, we were able to hand ventilate (Han grade 2) and maintain oxygenation without difficulty. With hindsight, we consider that in this case the incorrect airway plan may have been made.

FOI in this patient group was not always straightforward or predictable. An example is patient 6, who underwent an ankylosis release, a radial forearm free flap, and lip-plasty. She had a predicted difficult airway with complete trismus. Plan A was an awake nasal FOI. The distortion caused by the noma scarring made it impossible to pass the fiberoptic scope via the contralateral nostril. The tracheal tube was placed in the awake patient (with minimal sedation) via the noma defect (Fig. 2, see Supplemental Digital Content 2, http://links.lww.com/AA/A539, and 3, http://links.lww.com/AA/A540). This allowed surgery for trismus release to proceed. Subsequently, the endotracheal tube was repositioned to the contralateral corner of the mouth during the surgery, when mouth opening was restored to normal, to enable scar resection and free flap surgery.

**DISCUSSION**

Many anesthetic airway problems that occur during anesthesia are unexpected. Even when anticipated, airway difficulties may be compounded by poor planning. Given the obvious facial deformity seen in this patient population, and the setting in which we were working, our default position was to anticipate airway management difficulties and plan accordingly.

The DAS has published guidelines to aid decision making and planning when dealing with unexpected failed intubation. We adhered to the general algorithm suggested by the DAS, namely:

1. Initial intubation plan.
2. Secondary intubation plan.
4. Rescue technique for cannot intubate, cannot ventilate.

Because noma affects the anterior facial structures only, the airway assessment tests that focus on this area are of particular interest. A Mallampati score of 3 or 4 is associated with difficult laryngoscopy and difficult mask ventilation. Mallampati score was recorded on all patients, but we concluded it had only variable applicability. In our case series, we found Mallampati score to be a useful airway test, with the following proviso. Noma patients can have extensive facial tissue loss, including parts of the lower lip, jaw, cheek, upper lip, or nose. If the tissue loss includes the nose and upper lip, the Mallampati score becomes less helpful. This is demonstrated in Figure 3 (see Supplemental Digital Content 4, http://links.lww.com/AA/A541). This patient had a significant reduction in mouth opening, yet the posterior pharyngeal wall is clearly visible through the noma defect. Use of Mallampati score in this scenario is inappropriate, as by strict definition, the patient has a Mallampati score of 1, but clearly this may not be representative of the ease of laryngoscopy.

The original Mallampati paper referred to the size of the base of the tongue relative to the oropharynx. In cases such as the patient shown in Figure 1c (see Supplemental Digital Content 1, http://links.lww.com/AA/A538) with severe trismus and a bony ankylosis, the Mallampati score would predict difficult laryngoscopy, but for a different reason, namely the severely reduced interincisor gap. In some cases the interincisor gap was ascribed a negative value, because the jaw tends to fix in a position with the incisors overlapped. Generally, we considered the presence of a bony ankylosis to be an absolute indication for FOI, as access to the oropharynx for direct laryngoscopy is impossible. However, in one patient with trismus and nasal destruction, the alveolar defect was sufficient to allow the use of a Glidescope for oral intubation.

Bony ankylosis also adversely affects airway management via a second mechanism, namely it prevents jaw protrusion and thus the ability of the anesthesiologist to lift the tongue off the posterior pharyngeal wall. Severely limited mouth opening and inability to advance the mandible on the maxilla are strong predictors of airway difficulties and difficult mask ventilation. One might therefore assume that the presence of a bony ankylosis may predict difficult mask ventilation as well. However, in our experience, it is usually possible to maintain oxygenation and anesthesia in these patients either with spontaneous ventilation or by hand ventilation via a facemask, unless the defect itself makes obtaining a mask seal difficult. None of those who we attempted to mask ventilate were more difficult than Han grade 2.

Three patients whose initial plan (plan A) for airway management was awake FOI progressed to a plan B of asleep FOI. In these cases although awake FOI was in our view the ideal technique, once in the operating room, patient compliance became a concern. This was not least because Ethiopia has 46 languages in common use, and we only intermittently had translators available to help communication. It is recognized that one of the most important predictors of difficult FOI is a lack of patient cooperation, and in addition, we lacked drugs and infusion systems that would be used in our Western practice that make the process of awake intubation more tolerable. Where compliance could not be relied on, and as we gained some experience with the noma airway, we found that incremental propofol sedation progressing to general anesthesia and subsequent asleep FOI allowed us to maintain...
spontaneous ventilation and to assess the degree to which the airway could be maintained and controlled. When we had serious concerns over our ability to maintain the unintubated airway under anesthesia, we used careful incremental IV ketamine sedation. This also enabled maintenance of spontaneous respiration and allowed conscious compliance for FOI with topical anesthesia.

Asleep FOI has been considered by some authorities as suboptimal, because of concerns about potential obliteration of the pharyngeal cavity by airway collapse after induction of anesthesia.27,28

In our patient group, the posterior airway remained patent, perhaps aided by the lack of redundant pharyngeal tissue. These patients were universally of low or low-normal body weight. Although high BMI is associated with difficulties with airway management,25,29 a low BMI has not been shown to be associated with either difficult or conversely “easy” airway management. As discussed, noma is a condition that affects the anterior and superior airway structures only. However profound the lesion, from the pharynx downwards the airway is normal unless other pathology is present. In our view, this underpins the high degree of airway success in this series and makes noma the paradigmatic condition for asleep FOI.

The technique of fiberoptic laryngoscopy and intubation may require flexibility and some ingenuity in noma patients. The nasal route may be possible if the lesion is perioral, but may require flexibility and some ingenuity in noma patients. The nasal route may be possible if the lesion is perioral, but may require flexibility and some ingenuity in noma patients. The nasal route may be possible if the lesion is perioral, but may require flexibility and some ingenuity in noma patients.

The destructive nature of noma and the associated distorting scarring that occurs may make nasal FOI traumatic and difficult. Oral routes, such as gaps between missing teeth or via perioral defects, need to be considered as possible routes for FOI.

Incomplete airway assessment is associated with poor airway outcomes.23 Given the obvious facial disfigurement resulting from healed noma, it is easy to fixate on the noma lesion while neglecting to fully assess the airway. We stress the importance of a full airway assessment, because the extent of the external deformity is not necessarily indicative of the degree of difficulty that will be encountered during airway management. A patient with a severe deformity may have an airway that is easy to manage (Fig. 4, Supplemental Digital Content 5, http://links.lww.com/AA/A542, and 6, http://links.lww.com/AA/A543), while minimal external deformity may belie significant airway management difficulty, particularly when a bony ankylosis is present (Fig. 5, see Supplemental Digital Content 7, http://links.lww.com/AA/A544, and 8, http://links.lww.com/AA/A545). It is also possible that a second pathiology might be present that adds further challenges to airway management. We believe it is vital to observe and note the full complement of airway measurements to separate those whose airways will present difficulty from those whose airway management will be straightforward. Failure to do this may make a difficult noma airway into a potentially dangerous and near impossible one to manage.

There were several limitations to our study. The airway data collected were not exhaustive, but we felt it pragmatic within the setting in which we were working. Two consultant anesthesiologists working together performed the airway assessment and planning. This was partly for consistency and ease of data collection and partly to gain consensus for airway management. Interestingly, while one might expect consistency in objective physiognomic measurement between observers and good interobserver agreement for Mallampati classification, mouth opening and jaw protrusion has been previously demonstrated,30 we also found that there was a high degree of consistency in airway planning between the 2 consultants. Whether this consistency represented similar clinical experience and training leading to the (correct) assessment of what would ultimately be a successful airway technique or an example of “groupthink” is unknown.

We have shared our experiences and have addressed some of the particular airway challenges that noma presents. It is important to acknowledge that our airway planning, management, and, ultimately, success must be viewed from within the context in which we were working. The nature of the surgery necessitated an endotracheal tube being placed, and, as discussed, we had a large array of airway equipment available to us.

In a different context (e.g., the local Ethiopian anesthetic provider presented with a noma patient for non-noma surgery) where advanced airway techniques are not possible either due to lack of training and/or equipment, we would advocate minimal airway intervention, with regional techniques (where possible and appropriate) as arguably a safer option.

CONCLUSION

Noma remains a devastating and disfiguring disease that is largely preventable by improved nutrition. Reconstructive surgery for noma lesions can present airway challenges for the anesthesiologist. Airway difficulties can be compounded by poor airway planning. In this series, we have shown that structured assessment and careful planning can achieve a high rate of success with primary airway plans (plan A), with the majority of failures being successfully managed with a secondary airway plan (plan B). With this strategy, we avoided any episodes of lost airway, “cannot intubate, cannot ventilate” situation, or need for surgical airway rescue.

Because noma affects the anterior facial structures only, it is the airway assessment tests that focus on this area in particular that one would intuitively expect to be useful. Our experience supports this. Our airway management plans were particularly influenced by the interincisal distance and inability to sublux the mandible. FOI was the technique of choice where bony ankylosis was present and was safe and effective as the lower airway in noma survivors is normal. Facemask ventilation was universally straightforward (Han grade 1 or 2), possibly helped by the low or low-normal BMI found in these patients.

APPENDIX: SUPPLEMENTARY FIGURE LEGENDS

Figure 1. (c) External appearance. Written consent for publishing image has been obtained from the patient (see Supplemental Digital Content 1, http://links.lww.com/AA/A538).

Figure 2. (a) External appearance (see Supplemental Digital Content 2, http://links.lww.com/AA/A539); (b) Awake fiberoptic intubation via noma defect. Written consent for publishing image has been obtained from the patient (see Supplemental Digital Content 3, http://links.lww.com/AA/A540).
Figure 3. Posterior pharyngeal wall visible through noma defect. Written consent for publishing image has been obtained from the patient (see Supplemental Digital Content 4, http://links.lww.com/AA/A541).

Figure 4. (a) Severe external deformity but airway relatively straightforward – intubated using Glidescope on previous mission (see Supplemental Digital Content 5, http://links.lww.com/AA/A542). (b) External appearance following surgery. Written consent for publishing image has been obtained from the patient (see Supplemental Digital Content 6, http://links.lww.com/AA/A543).

Figure 5. (a) and (b). Young boy with minimal external deformity, but challenging airway due to bony ankylosis and complete trismus (see Supplemental Digital Content 7, http://links.lww.com/AA/A544, and 8, http://links.lww.com/AA/A545). Written consent for publishing image has been obtained from the patient.

DISCLOSURES
Name: Michael Howard Coupe, MBChB, FRCA, FFPMRCA, FFICM.

Contribution: Michael Howard Coupe was involved in the clinical care of the described patients, airway data collection, manuscript authorship, and subsequent manuscript review.

Attestation: Michael Howard Coupe approved the final manuscript. Michael Howard Coupe attests to the integrity of the original data and the analysis reported in this manuscript. Michael Howard Coupe is the archival author.

Name: Doug Johnson, MBChB, MRCP, FRCA.

Contribution: Doug Johnson was involved in the clinical care of the described patients, airway data collection, manuscript authorship, and subsequent manuscript review.

Attestation: Doug Johnson approved the final manuscript. Doug Johnson attests to the integrity of the original data and the analysis reported in this manuscript.

Name: Patrick Seigne, FFARCSI.

Contribution: Patrick Seigne was involved in the clinical care of the described patients, airway data collection, manuscript authorship, and subsequent manuscript review.

Attestation: Patrick Seigne approved the final manuscript.

Name: Bill Hamlin, MBChB, DRCOG, FRCA.

Contribution: Bill Hamlin was involved in the clinical care of the described patients, airway data collection, manuscript authorship, and subsequent manuscript review.

Attestation: Bill Hamlin approved the final manuscript.

This manuscript was handled by: Steven L. Shafer, MD.

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REFERENCES