Olfactory Meningioma Removal by Craniectomy and Craniotomy

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Missy—a 12-year-old, 32-kg (70.4-lb), spayed German shepherd—presented with a 3-month history of worsening seizures, which were previously well controlled with oral phenobarbitone (30 mg/kg). On the day of presentation, Missy had a generalized grand mal seizure lasting approximately 2 minutes, followed by two shorter seizures.

Missy was admitted to the hospital and administered IV phenobarbitone, diazepam, and fluid therapy. A complete blood cell count and a serum biochemistry profile revealed moderate neutrophilia; all other values were within normal limits. The neutrophilia indicated inflammation most likely associated with mild compression around a tumor, as there was no evidence of other clinical infection. The following day, chest radiography (FIGURE 1) showed no signs of metastatic disease, and abdominal ultrasonography revealed no abnormalities; however, computed tomography (CT) of the brain revealed a contrast-enhancing mass involving the right olfactory lobe and adjacent cortex (FIGURE 2).

The 3 × 2 × 1–cm mass was presumably causing a midline shift of the left cerebral hemisphere. The CT findings suggested a meningioma—possibly low grade, as the lesion appeared encapsulated and did not invade other tissues. Noninvasive, encapsulated brain tumors are typically low-grade meningiomas.1 Tumors that invade other tissues are typically high-grade meningiomas and appear invasive on contrast-study CT scans.

The Anesthetic Plan
Before Surgery
Before surgery, the following were administered:

- Methadone (0.3 mg/kg SC; a pure opioid agonist) for preemptive analgesia
- Mannitol (0.5 g/kg IV over 20 minutes) for osmotic diuresis and free radical scavenging2
- Glycopyrrolate (0.016 mg/kg SC) to help maintain heart rate and cardiac output3 during anesthesia; a decrease in heart rate (bradycardia) is expected with the use of an opioid CRI (fentanyl); the duration of action of glycopyrrolate is 2 to 3 hours4
- Phenobarbitone (15 mg/kg IV) to control seizures

Induction
For craniectomy and craniotomy, it is important to avoid increasing intracranial pressure (ICP). An increase in ICP increases the likelihood of cerebral ischemia (a decrease in the supply of blood and oxygen to the brain), which has lasting effects in patients.

To avoid an increase in ICP during induction and intubation, it is important for the patient to be adequately anesthetized beforehand (coughing due to a light anesthetic level can increase ICP5) and in lateral recumbency without elevation of the head (elevating the head can also increase ICP).6

Missy was preoxygenated for 10 minutes (4 L/min) via face-mask, and the staff ensured that she was not stressed by the mask because stress would have negated the purpose of preoxygenation. Anesthesia was induced with midazolam (0.2 mg/kg IV) and fentanyl (4 µg/kg IV) over 1 minute, followed by propofol (1 mg/kg IV).
Benzodiazepines (e.g., midazolam) decrease cerebral blood flow and ICP. A 10.5-mm, cuffed endotracheal tube was connected to an open circuit, and oxygen was delivered at a rate of 1.5 L/min. The endotracheal tube cuff was checked for a seal and inflated, and isoflurane was initiated at 1%. End-tidal carbon dioxide (ETCO2) monitoring was then initiated. Maintaining hypocapnia in the patient decreases cerebral blood flow, reducing the chance of cerebral edema. Methylprednisolone (30 mg/kg IV) was administered over 30 minutes to help reduce inflammation associated with surgery. This drug is typically given in a single dose.

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The arterial blood gas was analyzed to correlate the carbon dioxide (CO2) and oxygen levels with the multiparameter readings. IV fluid therapy (lactated Ringer solution) was increased to a surgical fluid rate (10 mL/kg/h). Cephalothin (22 mg/kg IV) was given for antibiotic coverage.

Missy was placed in sternal recumbency with care not to occlude the jugular vein (occlusion would increase ICP), and she was aseptically prepared for surgery.

After induction, a CRI of fentanyl (10 µg/kg/h) and propofol (4 mg/kg/h) was started to minimize use of a volatile agent (isoflurane) during surgery. Using a fentanyl and propofol CRI can depress ventilation, causing hypercapnia. The ETCO2 must be closely monitored to avoid hypercapnia.

Manual, intermittent positive-pressure ventilation was administered at 20 cm H2O; to avoid trauma to the lung tissue, this pressure should not be exceeded. One veterinary technician was responsible for ventilation, and another monitored the anesthetic depth. FIGURE 3 shows the surgical field.

A central venous catheter (7-French triple lumen) was placed in the left jugular vein. Once a tumor has been removed, there is less risk of increasing ICP by occluding the jugular vein. During postoperative care, it is helpful to monitor central venous pressure (CVP) to ensure that the patient maintains normovolemia (2 to 7 cm H2O). IV fluids and CRI drugs were infused through the central line, and the peripheral catheters were removed.

A nasal oxygen line was placed for potential use after extubation. A fentanyl patch (100 µg) was applied. Once it became active (12 hours after application), the fentanyl CRI was reduced and then stopped.

Monitoring equipment was used to ensure that anesthesia and analgesia were adequate. Missy’s heart rate was monitored by electrocardiography and esophageal stethoscope and remained between 100 and 110 bpm throughout surgery. If Missy had developed bradycardia, atropine (0.04 mg/kg IV) would have been administered. Atropine has a faster onset of action than glycopyrrolate.

Throughout anesthesia, Missy’s systolic arterial pressure was 90 to 105 mm Hg (normal range: 100 to 140 mm Hg) and mean arterial pressure was 68 to 80 mm Hg (normal range: 80 to 100 mm Hg). Hypotension was treated by administering synthetic
colloids (rather than crystalloids). Synthetic colloids were advantageous for treating hypotension in this case because they increase BP as a result of their large molecules, which keep them in the vessels longer. Fluid overload (hypervolemia) should be avoided because it increases CVP, which cannot be monitored during surgery because placement of a central venous line can occlude the jugular vein, increasing ICP. Hypertension associated with a light plane of anesthesia was treated by increasing the propofol CRI. If hypertension had been due to pain, the fentanyl CRI would have been increased. A fentanyl CRI can be safely increased to 20 µg/kg/h if needed; however, respiration should be closely monitored in non-ventilated patients because fentanyl is a potent respiratory depressant.

BP and heart rate should be evaluated together because they are closely related. An increase in BP and a decrease in heart rate could indicate fluid loading, requiring a decrease in the fluid rate. A decrease in BP and an increase in heart rate could indicate fluid or blood loss, requiring an assessment for hemorrhage. A synthetic colloid could be used to maintain intravascular oncotic pressure, but fresh whole blood should be used if it is available because it is better for replacing blood lost through hemorrhage.

Simultaneous decreases in BP and heart rate could indicate a deep plane of anesthesia. This could also be interpreted as myocardial depression on a graph of invasive BP (i.e. a slow increase in the systolic period of the graph, Figure 4). Absence of a dicrotic notch in the baseline may indicate the need to increase the blood volume. The patient and all physiologic values should be assessed before treatment is initiated.

ETCO₂ and oxygen saturation of hemoglobin (SpO₂) levels can mostly be controlled through ventilation, unless disturbances of these parameters are due to cardiac arrest. If lung function is normal before surgery, ventilation at the correct respiratory rate and tidal volume should maintain adequate oxygen and CO₂ levels. If hypercapnia is present, the respiratory rate and/or tidal volume should be increased to lower the CO₂ level. Hypocapnia causes intracranial vessels to constrict rather than dilate, which avoids cerebral edema. If the ETCO₂ level falls below 25 mm Hg, a decrease in the respiratory rate and/or tidal volume is necessary to elevate the ETCO₂ level to 25 to 35 mm Hg to avoid an excessive decrease in ICP. A dramatic decrease in the ETCO₂ level could indicate one of the following:

- Cardiac arrest, requiring cardiopulmonary resuscitation
- A disconnected monitoring device; all connections should be secured with tape and checked before the patient is draped for surgery
- A need to calibrate the multiparameter monitor

Missy was actively warmed once she was anesthetized. Normothermia (>96.8°F [>36°C]) should be maintained to allow better

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**Table 1. Patient Monitoring: Ideal Readings for Dogs**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Method of Measurement</th>
<th>Ideal Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen saturation of hemoglobin (SpO₂)</td>
<td>Pulse oximetry</td>
<td>95%–100%</td>
</tr>
<tr>
<td>Rate, rhythm, and electrical activity of the heart</td>
<td>Electrocardiography</td>
<td>~100–110 bpm</td>
</tr>
<tr>
<td>Invasive blood pressure</td>
<td>Direct measurement of arterial blood pressure</td>
<td>Systolic arterial pressure: &gt;90 mm Hg; mean arterial pressure: &gt;70 mm Hg</td>
</tr>
<tr>
<td>Core body temperature</td>
<td>Esophageal probe</td>
<td>&gt;96.8°F (&gt;36°C)</td>
</tr>
<tr>
<td>End-tidal carbon dioxide</td>
<td>Capnography</td>
<td>25–35 mm Hg</td>
</tr>
<tr>
<td>Heart rate</td>
<td>Esophageal stethoscope (directly monitors rhythm and sounds of the heart; useful when monitoring equipment is not functioning)</td>
<td>100–110 bpm</td>
</tr>
</tbody>
</table>

**Figure 4.** Graph showing normal invasive blood pressure. The upward trend corresponds to the systolic phase (depolarization of the ventricles), and the downward trend corresponds to the diastolic phase (blood volume; repolarization of the ventricles). The dicrotic notch in the diastolic period corresponds to closure of the aortic valve.
control of anesthesia and the patient's physiologic status. Normothermia can be maintained using the following methods:

- Applying bubble wrap to the extremities to avoid heat loss
- Warming IV fluids
- Heating the surgery table and/or using a commercial warming blanket during surgery

Postoperative Care
Missy was transferred to the intensive care unit for ongoing care. She continued to receive propofol and fentanyl by CRI at a reduced dose and was kept on a mechanical ventilator.

In addition to visual observation, the following were monitored postoperatively: heart rate, respiratory rate, Spo2 level, invasive BP, electrocardiogram, ETCO2 level, and CVP. In addition, the arterial blood gas values, packed cell volume, and total plasma proteins (a total of albumin and globulin) were monitored every 12 hours.

The propofol and fentanyl infusions were reduced over the next 12 hours. Missy was awake the next morning, extubated, and maintained on normal oxygen saturation without the use of nasal oxygen.

Outcome
Missy was kept in a quiet area of the intensive care unit and recovered well over the next 36 hours. She was transferred to the general ward 2 days after surgery and went home 5 days later with her very happy owners.

References
1. To help keep ICP within an acceptable range, the ETCO₂ level of craniotomy patients should be maintained at ______ mm Hg.
   A. 25 to 35  
   B. 35 to 40  
   C. 40 to 45  
   D. 45 to 50

2. Before surgery, mannitol can be used as
   A. an osmotic diuretic.  
   B. a synthetic colloid.  
   C. a free radical scavenger.  
   D. a and c

3. To avoid trauma to lung tissue during intermittent positive-pressure ventilation, a pressure of ____ cm H₂O should not be exceeded.
   A. 10.  
   B. 20.  
   C. 30  
   D. 40

4. The use of opioid agonists may result in
   A. hypercapnia.  
   B. bradycardia.  
   C. hypocapnia.  
   D. a and b

5. SC glycopyrrolate can have a duration of action of up to
   A. 1 hour.  
   B. 2 hours.  
   C. 3 hours.  
   D. 4 hours.

6. In this case, synthetic colloids were used instead of crystalloids
   A. to increase BP.  
   B. because synthetic colloids have larger molecules, which improves oncotic pressure.  
   C. to decrease BP.  
   D. a and b

7. A decrease in heart rate and an increase in BP could indicate
   A. an anesthetic overdose.  
   B. that the patient is in pain.  
   C. hypervolemia.  
   D. hypovolemia.

8. ICP can be increased by
   A. administration of a benzodiazepine.  
   B. jugular vein occlusion.  
   C. a decrease in the CO₂ level.  
   D. none of the above

9. To help prevent an increase in ICP during intubation, the patient should be
   A. adequately anesthetized.  
   B. in sternal recumbency.  
   C. in lateral recumbency.  
   D. a and c

10. A benzodiazepine can be used to decrease
   A. cerebral blood flow.  
   B. ETCO₂.  
   C. body temperature.  
   D. none of the above