A Comparison of Laser-Protected Endotracheal Tubes

James A. Burns, MD1, Stephen D. Adlard1, James B. Kobler, PhD1, Monica A. Tyman1, Robert H. Petrillo1, and Lauren F. Tracy, MD1

Abstract

Objectives. To compare the physical characteristics of 3 laser-protected endotracheal tubes (LPETs) commonly used in endoscopic laser surgery. To report potential intraoperative problems related to LPET use and suggest practical solutions.

Study Design. Comparative analysis.

Setting. Academic laboratory.

Subjects and Methods. Physical characteristics of the Mallinckrodt Laser-Flex (MTL), Medtronic Laser-Shield II (ML-II), and Rusch LaserTubus (RL) were compared. The effect of bending LPETs on airflow resistance was estimated with a pressure transducer. The force required to pull each tube through the glottis and the pressure exerted during this maneuver were measured in a fresh cadaveric human larynx.

Results. The design features and physical characteristics of LPETs differ, including varying balloon-tip lengths. Bending LPETs to acute angles caused significant pressure increase within the RL tube (Δ 3.42 cm H2O) and minimal change within the ML-II (Δ 0.12 cm H2O) and MTL (Δ 0.21 cm H2O) tubes. The average force required to pull the RL (48.12 g, P = .003) and MTL (282.4 g, P = .001) tubes through the glottis was 7.6× and 44.5× greater than that for the ML-II (6.39 g). When pulled through the vocal folds, the ML-II cuff exerted no detectable pressure, whereas higher pressures were measured for the RL (2.2 cm H2O) and MTL (6.5 cm H2O) tubes.

Conclusion. The ML-II tube had the most favorable characteristics, with minimal pressure during extubation and resistance to kinking. The RL tube kinks readily with a resultant increase in resistance to airflow. The MTL tube extends farther into the trachea due to a relatively elongated balloon-tip configuration. Future LPET designs should incorporate features that avoid intraoperative difficulties related to airway protection and ventilation.

Keywords
laser, endotracheal tube, intubation, endoscopic laryngeal laser surgery, transoral laser surgery

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Since their introduction to aerodigestive surgery by Strong and Jako in 1973,1 lasers have been used routinely during transoral endoscopic surgery. Using a laser in the confined space of the upper airway increases the risk of airway fire when all 3 elements of the classic fire triad are present—an oxidizer (oxygen), an ignition source (laser), and a fuel (endotracheal tube).2 To decrease the risk of endotracheal tube ignition, several laser-protected endotracheal tubes (LPETs) have been developed. Commonly used LPETs have included the Medtronic Laser-Shield II (ML-II; Medtronic Inc, Jacksonville, Florida), Rusch LaserTubus (RL; Teleflex Medical, Wayne, Pennsylvania), and Mallinckrodt Laser-Flex (MTL; Covidien, Mansfield, Massachusetts), all of which have distinct positive and negative attributes. The ML-II tube is no longer commercially available, and a recent survey of members of the American Broncho-Esophagological Association and the American Head and Neck Society who commonly utilize LPETs indicated that the ML-II tube had been used most often because it had advantageous physical dimensions and mechanical properties.3 The survey further reported that surgeons now use the RL and MTL tubes more frequently during endoscopic surgery.3

The laser-resistant properties of LPETs were reported, and the results showed that LPETs effectively resist ignition. However, the physical features of LPETs have not been compared, and it is important to identify which aspects of the remaining commercially available LPETs can lead to significant intraoperative problems. The purpose of this study is (1) to compare the physical dimensions and mechanical properties of 3 LPETs commonly used in...
endoscopic laser surgery, (2) to discuss potential intraoperative problems related to LPET use, and (3) to suggest practical solutions.

**Materials and Methods**

LPETs studied included the ML-II, RL, and MTL. We evaluated (1) the general physical dimensions, (2) the effect of bending the tube on intraluminal pressure under constant airflow as an indicator of flow resistance (simulated kinking of tube), (3) the pull-through force and pressure exerted on the glottis by a deflated cuff (simulated extubation), and (4) the time to deflate the cuff. This study was exempted from Massachusetts General Hospital Institutional Review Board approval.

**Comparison of Physical Characteristics**

Tube length, inner/outer diameter, wall thickness, tube material, cuff configuration, distance from proximal border of the cuff to tip of the tube, and laser-resistance mechanism were determined for each LPET and are compared in Table 1. Tube length and distance from proximal cuff to tube tip were directly measured and correlated to upper airway anatomy by laying the tube against a sagittally opened fresh human cadaveric larynx (68-year-old woman) in a simulated intubation position (Figure 1). Inner/outer diameter and tube wall thickness were measured at the middle of each tube after transection of each tube perpendicular to its long axis. Tube material, cuff configuration, and laser-resistance mechanism were recorded from the product package insert. Tip compliance measures are from Friedman et al.3

**Effect of Bending on Intraluminal Air Pressure (Simulated Kinking of Tube)**

Intraluminal pressure was compared before and after bending LPETs through various angles. The impact of bending the LPETs on intraluminal pressure was measured for 2 tube sizes (4.0 and 5.0). Each LPET was connected to 11-mm-diameter tubing, which was attached to a regulated air source with a constant flow rate of 15 L/min. The LPETs were removed from packaging and secured with their inherent curvature on a platform. A calibrated pressure catheter (Mikro-Tip; Millar, Houston, Texas) was then introduced through the LPET distal to proximal so that the transducer was located at the proximal end of the tube. Output of the transducer was recorded with a programmable amplifier/filter and data acquisition system (Molecular Devices, San Jose, California). The RL tube was bent until kinking was observed (similar to our clinical observation; Figure 2A), and the distance between the proximal and distal ends was measured. The MTL and ML-II tubes were bent until a similar proximal-distal distance was achieved and the pressures were recorded (Figure 3). Pressures were also measured with the tubes bent to an intermediate position between each tube’s inherent curvature and the bend that produced kinking in the RL tube. Pressure measurements were repeated 3 times for each LPET, and the mean intraluminal pressure was calculated.

A mixed-design analysis of variance (ANOVA) was used to determine the effect of endotracheal tube (MTL, RL, ML-II), size (4- vs 5-mm inside diameter), and bending (inherent curve vs maximum bend) on airflow. The

<table>
<thead>
<tr>
<th>Tube material</th>
<th>MTL</th>
<th>RL</th>
<th>ML-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cuff configuration</td>
<td>Stainless-steel spiral; cuff, PVC</td>
<td>Rubber latex/copper foil; Merocel sponge (distal, 17 cm); cuff, latex rubber</td>
<td>Silicone rubber/aluminum; wrapped seamless Teflon; cuff, Silicon</td>
</tr>
<tr>
<td>Cuff deflated</td>
<td>Dual: in series</td>
<td>Dual: inner and outer</td>
<td>Single: methylene blue crystals</td>
</tr>
<tr>
<td>Tube length, cm</td>
<td>34.9</td>
<td>40.0</td>
<td>32.5</td>
</tr>
<tr>
<td>Tip compliance&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Collapses and forms stiff ridges</td>
<td>Collapses and forms stiff ridges</td>
<td>Smooth and tight to shaft</td>
</tr>
<tr>
<td>Cuff-to-tip length, mm&lt;sup&gt;c&lt;/sup&gt;</td>
<td>60.5</td>
<td>54.9</td>
<td>53.5</td>
</tr>
<tr>
<td>Distal tip length, mm&lt;sup&gt;d&lt;/sup&gt;</td>
<td>17.2</td>
<td>16.7</td>
<td>25.3</td>
</tr>
<tr>
<td>Inner diameter, mm</td>
<td>4.0 → 5.0 → NA</td>
<td>4.0 → 5.0 → 7.0</td>
<td>4.0 → 5.0 → 7.0</td>
</tr>
<tr>
<td>Outer diameter, mm</td>
<td>6.5 → 7.5</td>
<td>8.0 → 9.0 → 12.0</td>
<td>6.6 → 8.0 → 10.5</td>
</tr>
<tr>
<td>Wall thickness, mm</td>
<td>1.25 → 1.25</td>
<td>2.0 → 2.0 → 2.65</td>
<td>1.3 → 1.5 → 1.75</td>
</tr>
<tr>
<td>Maximum diameter, mm&lt;sup&gt;e&lt;/sup&gt;</td>
<td>24</td>
<td>28</td>
<td>6.6 → 8.0 → 10.5</td>
</tr>
<tr>
<td>Laser-resistance mechanism</td>
<td>Reflection of defocused beam</td>
<td>Absorbed by Merocel, reflected by copper</td>
<td>Absorbed by Teflon, reflected by aluminum</td>
</tr>
</tbody>
</table>

**Table 1. Comparative Physical Characteristics of 3 Commonly Used Laser-Protective Endotracheal Tubes.**

Abbreviations: ML-II, Medtronic Laser-Shield II; MTL, Mallinckrodt Laser-Flex; RL, Rusch LaserTubus; PVC, polyvinyl chloride; NA, not available; Silicone, soft silicone.

<sup>a</sup>Information courtesy of Medtronic Inc, Teleflex Medical, and Covidien.

<sup>b</sup>Data from Friedman et al.3

<sup>c</sup>Measured from proximal cuff attachment to tip of tube (Figure 2).

<sup>d</sup>Measured from proximal cuff attachment to tip of tube (Figure 2).

<sup>e</sup>MTL and RL have an attached anesthesia circuit connector, while ML-II has a removable connector.
repeated-measure factors were mean airflow when the tubes were straight and bent, and the between-groups factors were endotracheal tube and size. The interaction effect of interest was the 3-way interaction of tube size bending.

Lower-order 2-way interaction effects and main effects were investigated only if the 3-way interaction of interest was not statistically significant. Effect sizes for interactions and main effects were quantified with the partial eta square ($\eta^2$), and values of 0.01, 0.09, and 0.25 were interpreted as small, medium, and large, respectively. A predetermined level of statistical significance ($P < .05$) was used for all analyses. All post hoc analyses were completed with Bonferroni corrected $t$ tests.

**Pull-Through Force and Pressure Exercised on Glottis with Deflated Cuff (Simulated Extubation)**

The force required to pull a size 5.0 tube of each type through the vocal folds and the pressure exerted by the vocal folds on the cuff during this maneuver (simulated extubation) were measured. A fresh human cadaveric larynx (68-year-old woman) was placed in a custom larynx holder, which held the thyroid and cricoid cartilages firmly via corkscrew-tipped rods inserted into the cartilages. The force required to pull each tube vertically through the vocal folds was determined by recording the output of the digital force sensor (FORT1000; World Precision Instruments, Sarasota, Florida) attached to each tube with the sensor output directed to the previously mentioned data acquisition system. The peak value over the course of the pull-through was measured and converted to grams based on the calibration data.

The cuffs were maximally deflated, and the force sensor and attached tube were slowly withdrawn from the larynx with the crank arm of a Linhof Studiomatic camera stand. For estimating the pressure exerted on the cuff by the glottal tissues, a pressure catheter (Mikro-Tip; Millar, Houston, Texas) was connected to the pilot balloon, which had been filled with saline and then deflated, via a 3-way stopcock. Figure 4 depicts the experimental setup for measuring the pulling force and the pressure exerted on the cuff. The pull-through maneuver was repeated 3 times for each tube. The larynx was inspected after each trial and confirmed to have incurred no physical damage or change in glottic configuration.

Three ANOVAs were used to determine the effects of the manual force required for tube removal among the tube types and the amount of pressure exerted on the larynx during tube removal.

**Time to Deflate LPET Cuff**

The time required to remove 10 mL of saline from the cuff of each size 5.0 tube was measured. In the senior author’s clinical practice, this size is the most commonly used. To standardize the withdrawal of saline with a 10-mL syringe, the plunger was pulled back rapidly to the 10-mL mark and held there while the time to filling was measured by an assistant using a stopwatch. The RL and MTL each have 2 cuffs, which are identical size in the MTL whereas the RL tube has a large outer cuff and smaller inner cuff; only the large outer cuff (RL tube) and the proximal cuff (MTL tube) were measured. Three ANOVAs were used to determine the effects of different tube type on cuff deflation time (in seconds).

**Results**

**Comparison of Physical Characteristics**

The comparative physical characteristics of the LPETs are recorded in Table 1. The RL tube is longer (40 cm) than the MTL (34.9 cm) and ML-II (32.5 cm) tubes, and the bulky stopcock mechanism for balloon inflation makes the
The MTL tube has a thickened band of metal at the attachment site of the proximal balloon, which must be placed below the glottic level during intubation. This metal band with the double-balloon configuration makes the distance from the proximal cuff to the tube tip 5 mm longer than the RL and ML-II tubes, both of which have a single outer balloon and no thick band of material at the balloon attachment site. When correlated to upper airway anatomy, the MTL tubes extended >1 tracheal ring farther than the ML-II tube.

Effect of Bending LPETs on Intraluminal Pressure

The effect of bending on intraluminal pressure is shown in Table 2. The mixed-design ANOVA indicated a statistically significant tube × size × bending interaction effect, $F(2, 6) = 15.27, P = .004$. The associated effect size was large ($\eta^2 = 0.84$). The RL tube kinked easily and had significantly increased pressure above the kinks ($\Delta 3.42 \text{ cm H}_2\text{O}$, size 5.0) as compared with the MTL ($\Delta 0.21 \text{ cm H}_2\text{O}$) and ML-II ($\Delta 0.12 \text{ cm H}_2\text{O}$) tubes, which did not kink (even at the most severe bend; Figure 3). The MTL and ML-II tubes of all sizes had essentially no change in intraluminal pressure during maximum bending, which correlated with the observation that these tubes resist kinking. Across all 3 types of LPET, increase in intraluminal pressure with bending was inversely proportional to tube diameter.

Pull-Through Force and Pressure Exerted on Glottis with Deflated Cuff (Simulated Extubation)

The mean force required to pull the RL (48.12 g, $P = .003$) and MTL (282.4 g, $P = .001$) tubes through the glottis was 7.6× and 44.5× greater than for ML-II (6.39 g). The ANOVA indicated a significant main effect of tube type, $F(1, 2) = 578.23, P < .001$, with an associated large effect size ($\eta^2 = 0.99$). There was significantly lower force exertion for the ML-II tube as compared with the MTL (mean, $\Delta 276.1 \text{ g}$, $P = .003$) and RL (mean, $\Delta 41.7 \text{ g}$; $P = .006$) tubes. Additionally, the MTL required significantly more force than the RL (mean, $\Delta 234.3 \text{ g}$; $P = .003$).

When pulled through the vocal folds, the ML-II tube’s cuff exerted no detectable pressure (mean, $0.0 \text{ cm H}_2\text{O}$) on the vocal fold, whereas higher pressures were measured for the RL (mean, 2.2 cm H$_2$O) and MTL (mean, 6.5 cm H$_2$O) tubes. The ANOVA for pressure exerted on the larynx during extubation indicated a significant main effect of tube type, $F(1, 2) = 37.12, P < .001$, with an associated large effect size ($\eta^2 = 0.92$). The difference between the ML-II and MTL (mean, $\Delta 6.4 \text{ cm H}_2\text{O}$; $P = .041$) and the RL (mean, $\Delta 2.2 \text{ cm H}_2\text{O}$; $P = .009$) was statistically significant. There was no statistically significant difference between the RL and MTL. The deflated balloons of the RL and MTL tubes were observed to form stiff ridges that impinged on the glottal tissues during withdrawal. In comparison, the ML-II tube cuff is tight to shaft and exerted significantly less pressure against the glottis (Figure 5).

Time to Deflate LPET Cuff

The ML-II required the shortest time to deflate the cuff, averaging 10.5 seconds. This was significantly less than the time to deflate the outer RL cuff (mean, 15.1 seconds; $P < .001$) and proximal MTL (mean, 17.5 seconds; $P < .001$). Also, the time to deflate the RL cuff was significantly lower than that for the MTL (mean, 2.5 seconds; $P = .004$). The ANOVA for cuff deflation time indicated a significant main effect of tube type, $F(1, 2) = 62.50, P < .001$, with an associated large effect size ($\eta^2 = 0.93$).

Discussion

Comparison of the 3 LPETs most commonly used in endoscopic laser surgery reveals significant differences that potentially lead to intraoperative problems if the surgeon is unfamiliar with the specific physical characteristics and mechanical properties. Since the most commonly used
LPET, the ML-II, is no longer commercially available, surgeons must now utilize the 2 remaining LPETs: RL and MTL. A recent survey of members from the American Broncho-Esophagological Association and the American Head and Neck Society who utilize LPETs showed that the RL and MTL tubes do not have many of the most highly valued attributes. This study reports results comparing specific physical characteristics and mechanical properties to better familiarize endoscopic laser surgeons with these LPETs.

The physical characteristics shown in Table 1 differ considerably among the LPETs. All 3 tubes utilize different laser-resistant material. The MTL tube has ridges due to the coiled nature of its construction, and this feature can cause abrasions in the pharynx. Care must also be taken at the lip, because the grooves between ridges of coiled metal can pinch soft tissue where the tube bends. The RL tube’s laser-resistant material is a copper wrap covered by latex coating proximally and a Merocel sponge distally. The latex coating prohibits use of the RL tube in patients with latex allergy. Since the Merocel material can stick to pharyngeal mucosa during intubation, the manufacturer recommends wetting the tube—a maneuver that can increase the outer diameter of the tube by 2 mm due to swelling. The ML-II tube is wrapped in laser-resistant aluminum with a Teflon coating. The RL and ML-II tubes’ outer coating can be avulsed from the underlying foil layer, which can then reflect laser light and cause thermal damage. The ML-II tube also has 1.0 cm of non-laser-protected silicone proximal to the cuff, which requires...
the additional step of covering with saline-soaked pledgets for optimal laser safety.

Additionally, the RL and ML-II tubes connect the pilot balloon with the cuff via a channel within the wall, whereas the MTL tube’s connecting-tubing runs within the lumen. Figure 6 reveals that the MTL tube has 2 tubes within its lumen, whereas the RL and ML-II cuff-inflating tubes are placed within the tube wall. Prolonged contact of the laser on the shaft of the MTL tube was hypothesized to heat the plastic tubing within the lumen and prevent cuff deflation.10 Additionally, the intraluminal presence of connecting tubing in the MTL decreases the functional inner diameter which can create difficulty for Seldinger technique intubation or the use of flexible fiberoptic intubation. ML-II tubes use dried methylene blue dye in the pilot balloon; methylene blue crystals previously occluded the pilot tube, which resulted in inability to deflate the cuff.11 The ML-II tube has a removable anesthesia circuit adapter, a feature that enables the tube to fit through a small monocular scope in cases with difficult endoscopic exposure or during tube exchanges. The anesthesia circuit adapters of the MTL and RL tubes cannot be removed, and the associated increase in tube diameter can limit their utilization through laryngoscopes.

Measures of the distance from the tube tip to the proximal balloon showed a significantly longer length of tube extending beyond the vocal cords for the RL and MTL tubes as compared with the ML-II tube (Figure 1). Therefore, these tubes can be more easily inserted too far into the trachea or bronchus and adversely affect ventilation. In contrast, with the shorter overall length of the ML-II, care should be taken to check the position of the tube after neck extension during endoscopic laryngeal surgery when

Table 2. Impact of Bending the Laser-Protective Endotracheal Tubes on Intraluminal Pressure.

<table>
<thead>
<tr>
<th>Tube: Angle</th>
<th>4 mm</th>
<th>5 mm</th>
<th>7 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No bend</td>
<td>13.10 (0.27)</td>
<td>8.04 (0.04)</td>
<td>NA</td>
</tr>
<tr>
<td>Half bend</td>
<td>13.28 (0.37)</td>
<td>8.63 (0.05)</td>
<td>NA</td>
</tr>
<tr>
<td>Maximum bend</td>
<td>15.04 (0.09)</td>
<td>8.25 (0.47)</td>
<td>NA</td>
</tr>
<tr>
<td>RL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No bend</td>
<td>13.30 (0.17)</td>
<td>4.99 (0.38)</td>
<td>0.47 (0.07)</td>
</tr>
<tr>
<td>Half bend</td>
<td>16.46 (0.43)</td>
<td>5.29 (0.06)</td>
<td>0.63 (0.08)</td>
</tr>
<tr>
<td>Maximum bend</td>
<td>19.19 (0.27)</td>
<td>8.41 (0.36)</td>
<td>0.70 (0.08)</td>
</tr>
<tr>
<td>ML-II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No bend</td>
<td>7.1 (0.14)</td>
<td>3.73 (0.41)</td>
<td>0.17 (0.26)</td>
</tr>
<tr>
<td>Half bend</td>
<td>7.44 (0.07)</td>
<td>3.78 (0.23)</td>
<td>0.16 (0.12)</td>
</tr>
<tr>
<td>Maximum bend</td>
<td>7.34 (0.54)</td>
<td>3.85 (0.02)</td>
<td>0.14 (0.14)</td>
</tr>
</tbody>
</table>

Abbreviations: ML-II, Medtronic Laser-Shield II; MTL, Mallinckrodt Laser-Flex; NA, not available; RL, Rusch LaserTubus.
the ML-II tube is utilized. Figure 2 demonstrates the eccentric movement of the distal tube tip with inflation of the proximal MTL cuff and ML-II cuff. In contrast, the tip of the RL tube remains centered within the tracheal lumen when the outer cuff is inflated.

During bending of the LPETs, the RL tube was noted to kink easily, and the pressure measurements indicate that this increases resistance to airflow. Kinking of the RL tube was noted clinically, with the problem occurring at the junction between the rigid plastic proximal end and the softer Latex distal end. This junction is usually located at the patient’s lips after intubation, and the tube bends readily, owing to the “top-heavy” nature of the tube with its 2 bulky pilot balloons, as well as traction from the anesthesia circuit tubing (Figure 2A). Use of an anesthesia circuit tree can be used to help support the proximal tube and prevent kinking (Figure 2B). The MTL and ML-II tubes resisted kinking when bent to similar angles as the kinked RL tube.

Complete cuff deflation during extubation is important to maximally decrease diameter and limit friction against the vocal folds, especially during direct glottic surgery with microflap creation or delicate surgical site. The RL and MTL deflate to a ridged, stellate configuration, while the ML-II is circular and smooth because the silicone balloon is more elastic and deflates down tight to the shaft of the tube. Despite decreasing the cuff size to the greatest degree, the cuffs of the RL and MTL tubes exerted some pressure against the glottis during simulated extubation in comparison with the ML-II, which exerted no pressure. Accordingly, increased force was required to remove the RL and MTL tubes through the cadaveric glottis. While the pull-through force and intraballoon pressures were measured only during simulated extubation in this study, the same forces would theoretically apply during intubation as well.

The product guidelines for inflation of LPET cuffs recommend instilling the smallest amount of saline necessary to create an effective seal against the tracheal mucosa. A specific volume is not recommended, since different tracheal diameters may require varying amounts of saline to prevent air leakage. The tubing that connects the pilot balloon to the distal cuff is narrow, thereby requiring more time to remove saline from the cuff than to remove air. The RL and MTL tubes took about 17 seconds to completely remove 10 mL of saline from 1 balloon, whereas the ML-II tube took about 10 seconds. If both balloons in the RL and MTL tubes are inflated, the total time for deflation would be even longer. All members of the team involved with extubating these patients should be aware of the prolonged time needed to completely remove all saline to avoid glottic injury during extubation.

There are some limitations acknowledged in this study. Ideally, LPETs of size 6.0 would be included; however, 6.0 ML-II was not available due to discontinuation of the product. Comparison of size 7.0 LPETs was therefore done; however, the MTL is not available at this size. Despite these drawbacks, we believe that this investigation herein demonstrates substantial differences among LPETs that may guide a surgeon’s choice of LPET and aid in troubleshooting complications.

Conclusion

Of the tubes tested, the ML-II tube showed resistance to kinking and caused minimal trauma to the glottis in comparison with commercially available tubes. The RL tube cannot be used in patients with latex allergy and kinks readily with a resultant increase in resistance to air flow. The MTL tube requires a significantly longer time for cuff deflation and extends farther into the trachea due to the greater distance from the proximal balloon and tube tip. Future LPET designs for use during transoral laser surgery should incorporate features that minimize pressure on the vocal folds during intubation/extubation and avoid intraoperative difficulties related to airway protection and ventilation.

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Author Contributions

James A. Burns, conception and design, interpretation of data, accountable for content, drafting/revising manuscript, final approval of manuscript; Stephen D. Adlard, conception, revising manuscript, accountable for content, final approval of manuscript; James B. Kobler, design, analysis/interpretation of data, critical revising manuscript, accountable for content, final approval of manuscript; Monica A. Tynan, design, acquisition of data, revising manuscript, accountable for content, final approval of manuscript; Robert H. Petrillo, design, acquisition of data, revising manuscript, accountable for content, final approval of manuscript; Lauren F. Tracy, conception and design, acquisition/interpretation of data, drafting/revising manuscript, accountable for content, final approval of manuscript.

Disclosures

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