geometry that mirrors the human hand to facilitate manipulation during laryngoscopy. The light source and camera from a digital bronchoscope inserted within bronchial lumen of the DLT guides the advancement of the DLT across the oral cavity and pharynx inside the handle and blade of the M3DPL (Fig 3; Video 1).

Finally, the metal 3D printed part was sequentially tested for proof of concept using an airway-training mannequin (AirSim Advance Bronchi X; True Corp). Intubations were successfully performed using both single-lumen tubes and DLTs sizes 35, 37, and 39F (left and right).

There are numerous advantages to using M3DPL for DLT intubations. First, there is more space available in the oropharynx because the DLT containing the bronchoscope is advanced inside the blade as opposed to side-by-side as with a video laryngoscope. Second, no stylet is required for the insertion of the DLT reducing risk of injury.

Finally, The DLT final positioning and verification can be guided during the initial placement with the digital bronchoscope, decreasing apnea time.

Metal 3D printing allowed us to make a geometric shape otherwise not feasible by traditional manufacturing techniques. The relatively low cost of research and development of novel devices using 3D printing allows the clinician to be in forefront of design process and perfecting new devices to facilitate our work and make patient care safer.

Conflict of Interest

Caroline A. Walker, MD: I have no financial interests to disclose.
Luiz Maracaja, MD: Founder and Medical Advisor of Vida Medical Devices, Medical Advisor of IRTRONIX.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1053/j.jvca.2019.06.013.

Caroline A. Walker, MD
Luiz Maracaja, MD
Yale School of Medicine, Department of Anesthesiology, New Haven, CT

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Apical Ballooning Following Mitral Valve Reoperation

To the Editor:

A 68-year-old woman with failure of a biologic mitral valve (Carpentier-Edwards Perimount Magna; Edwards Lifesciences, Irvine, CA) underwent redo mitral surgery 22 months after the first operation. The biologic valve was replaced with a St Jude mechanical valve prosthesis (Abbott Laboratories, North Chicago, IL). Although the postoperative period after the first operation was uneventful, except for transitory left hemiparesis, immediately after the second operation high doses of inotropic agents were needed to treat a low cardiac output associated with apical ballooning detected by transesophageal echocardiography. Anterolateral T-wave inversion was shown at electrocardiographic assessment and left ventricular dysfunction was detected, as well as apical ballooning was confirmed with transthoracic echocardiography (Fig 1). No coronary stenosis was found at coronary angiography. Both the clinical symptoms and monitoring changes disappeared within 2 weeks (Fig 2).

The present authors have no convincing theories to explain the early calcific degeneration of the biologic valve, nor to explain the onset of the Takotsubo-like syndrome following the second valve replacement. In addition to hypertension and
Fig 1. Apical ballooning associated with anterolateral negative T waves.

Fig 2. Echocardiographic and electrocardiographic normalization.
chronic lung disease, the patient suffered from no relevant comorbidities, except for post-traumatic epilepsy on pharmacologic therapy and atrophic gastritis needing periodic transfusions. Between the first and the second cardiac operation, the patient underwent total thyroidectomy (Hürthle cell carcinoma), which was combined with surgical excision of the inferolateral parathyroid glands. Because there were frequent episodes of hypocalcemia postoperatively, and one hospital admission from vitamin D intoxication, significant imbalance of calcium metabolism despite hormone replacement therapy was hypothesized.  

Conflicts of Interest

There is no conflict of interest to declare.

References


Luca Dell’Angela, MD*
Giuseppe Gatti, MD†
Marco Morosin, MD†
Gerardina Lardieri, MD‡
*Division of Cardiology, Emergency Department, Gorizia – Monfalcone Hospital, A.A.S.2, Gorizia, Italy
†Cardiovascular Department, “Ospedali Riuniti” University Hospital, A.S.U.I.T.S., Trieste, Italy
‡Letters to the Editor / Journal of Cardiothoracic and Vascular Anesthesia 34 (2020) 300–313

Airway Management and Positive Pressure Ventilation in Severe Right Ventricular Failure: SAVIOR Algorithm

To the Editor:

Intubation and mechanical ventilation is often necessary and potentially life saving in the management of decompensating critically ill patients with poor respiratory and or cardiovascular reserve. The advantages gained by sedation and paralysis need to be balanced with the alterations in preload and afterload associated with these medications. This becomes particularly important in patients with severe or unstable right ventricular (RV) failure. Recommendations and case studies regarding the management of these difficult to treat patients are lacking. Without recommendations or standardized methods in addressing patients with severe RV failure, poor outcomes secondary to complete cardiovascular collapse are inevitable.

The SAVIOR algorithm (Fig 1) was developed to standardize an approach to the complex cardiopulmonary effects of sedation, paralysis, mechanical ventilation, and positive pressure ventilation in critically ill patients with severe RV dysfunction. “SAVIOR” is an acronym for the four main concepts that the protocol is built upon: spontaneous, awake ventilation, inotropic support, and optimized respiratory physiology. Spontaneous, awake ventilation is utilized because of the low pressure, high-compliance nature of the RV. Use of positive pressure in the setting of a failing RV rapidly increases RV afterload leading to RV dilation, interventricular septum bowing, and potential cardiovascular collapse.

SAVIOR separates the components of sedation, paralysis, and positive pressure. Awake intubation is accomplished with airway topicalization using nebulized lidocaine followed by direct intubation of the vocal cords through a bronchoscope over which an endotracheal tube (ETT) is advanced once the carina is visualized. After the securement of the ETT, a slow ventilator initiation strategy is used starting in pressure support mode 0/0 with a $FIO_2$ of 100%. Over 20 to 30 minutes, pressure support is slowly titrated up and $FIO_2$ weaned to maintain a saturation of 88% to 92% in order to minimize deadspace ventilation. In addition, an inhaled vasodilator is connected to the ventilator circuit leading to reduced RV workload, increased pulmonary blood flow, and improved subsequent left ventricular preload.

The “I” portion of the algorithm is less clear, more controversial, and likely depends significantly upon the patient population. In our institution, pulmonary hypertension is quite common owing to smoking and coal mine exposure. There is evidence suggesting that increasing aortic afterload increases RV output prompting the early use of inotropes in this patient cohort. The principal goal in patients with severe RV failure is to maximize RV output without increasing RV afterload. A primarily inotropic dose of epinephrine at up to 0.08 $\mu g/kg/min$ is used for its predominant beta-receptor effect. If additional inotropic support is necessary, dopamine is chosen at an inotropic dose. The combination of epinephrine and dopamine provide an added benefit of afterload reduction owing to beta-2 receptor agonism, which is missed with the common combination of dobutamine and norepinephrine. Because of the paucity of receptors in the pulmonary vasculature, vasopressin can be used for continued systemic hypotension. With preserved systemic blood pressure, vasopressin is an additional consideration.

The SAVIOR algorithm is a standardized approach to provide guidance in airway management in patients with difficult to treat physiologic abnormalities. Some combination of the ideas may be useful across the spectrum of patients who require airway management in the setting of pulmonary hypertension, RV dysfunction, and hypotension. Further studies are required to elucidate the efficacy of the various portions of the algorithm in these critically ill patients. In our own case series, we have seen impressive success.