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Contents

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CASE REPORT

Contents

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ABOUT COVER

Editorial Board Member of *World Journal of Anesthesiology*, Mussarat Afzal, MD, Academic Research, Doctor, Department of Anesthesia, Prince Mohammed bin Abdulaziz Hospital-Riyadh, Riyadh 11676, Saudi Arabia. dr_mussarat_a@hotmail.com

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WJA mainly publishes articles reporting research results and findings obtained in the field of anesthesiology and covering a wide range of topics including critical medicine, orthopedic anesthesia, tumors and anesthesia, airway management, pediatric anesthesia, geriatric anesthesia, anesthesia for organ transplantation, regional anesthesia, anesthesia for neurosurgery, cardiothoracic anesthesia, obstetric anesthesia, pain diagnosis and treatment, and pharmacology in anesthesia.

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CASE REPORT

Intraoperative management of liver transplant in a patient with an undiagnosed ventricular septal defect: A case report

Tejal Vivek Desai, Achal Dhir, Douglas Quan, Raffael Zamper

ORCID number: Tejal Vivek Desai 0000-0003-3572-452X; Achal Dhir 0000-0001-5327-6420; Douglas Quan 0000-0002-9982-3159; Raffael Zamper 0000-0003-2783-3072.

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Tejal Vivek Desai, Achal Dhir, Raffael Zamper, Department of Anesthesia and Perioperative Medicine, University Hospital, London Health Sciences Centre, London N6A 5A5, Ontario, Canada

Douglas Quan, Department of General Surgery, University Hospital, London Health Sciences Centre, London N6A 5A5, Ontario, Canada

Corresponding author: Tejal Vivek Desai, DA, DNB, MBBS, Doctor, Research Fellow, Department of Anesthesia and Perioperative Medicine, University Hospital, London Health Sciences Centre, 339 Windermere Road, London N6A 5A5, Ontario, Canada.
tejaldesai7@gmail.com

Abstract

BACKGROUND

The intraoperative management of patients undergoing orthotopic liver transplantation (OLT) frequently encounters hemodynamic instability after reperfusion of the new liver graft. The resulting post-reperfusion syndrome is characterized by an increase in pulmonary vascular resistance and decrease in systemic vascular resistance. In the presence of a left to right intracardiac shunt, this hemodynamic perturbance can lead to shunt reversal followed by hypoxemia and embolization of air and debris into the systemic circulatory system.

CASE SUMMARY

A 43 years-old male with end-stage liver disease due to primary sclerosing cholangitis complicated by portal hypertension and hepatocellular carcinoma presented for an OLT. A bedside transthoracic echocardiography (TTE) was performed immediately before the procedure and unexpectedly identified a ventricular septal defect (VSD). The patient and the surgical team agreed to proceed with the surgery as it was a time critical donation after circulatory organ death. We developed an intraoperative plan to optimize pulmonary and systemic pressures using vasoactive support, optimized mechanical ventilation, and used transesophageal echocardiography (TEE) for intraoperative monitoring. During reperfusion, considerable turbulent flows with air were noted in the right ventricle, but no air was visualized in the left ventricle. Color flow Doppler showed no reversal flow in the VSD. At the end of the procedure, the patient was extubated in the operating room without complication and was transferred to the transplant unit for recovery.

CONCLUSION

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Our case highlights the importance of echocardiography in the perioperative assessment of patients undergoing liver transplantation. The TTE findings obtained immediately before the procedure and the real-time use of intraoperative TEE to modify our management during the critical phases of the transplant resulted in continuity of care and a good surgical outcome for this patient.

Key Words: Liver transplant; Ventricular septal defect; Transesophageal echocardiography; Intracardiac shunt; Paradoxical embolism; Case report

Core Tip: A liver transplant is a challenging case which can involve significant hemodynamic instability. It is also a situation where organ waitlists can prolong time to surgery leading to significant deterioration of the recipient's condition. This can be compounded by any unexpected cardiac findings diagnosed in the immediate preoperative period by echocardiography. Our findings of a ventricular septal defect on transthoracic echocardiography (TTE) led to a clinical dilemma of proceeding with surgery knowing there was a risk of paradoxical embolism or hypoxemia. On the other hand, rejecting a matched donation after circulatory death liver graft would have been a waste of precious resources. By using intraoperative transesophageal echocardiography (TEE) we carefully titrated intraoperative hemodynamics and prevented intracardiac shunting. Our case highlights the importance of bedside TTE as well as intraoperative TEE in patients undergoing orthotopic liver transplants.

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INTRODUCTION

The intraoperative hemodynamic management of patients undergoing orthotopic liver transplantation (OLT) is challenging and often involves significant instability. After reperfusion of the graft, post-reperfusion syndrome can occur which is characterized by an increase in pulmonary vascular resistance (PVR), central venous pressure (CVP) and pulmonary artery pressure, as opposed to a decrease in systemic vascular resistance (SVR)[1].

Amongst the cardiovascular diseases, intracardiac shunts are less common in OLT candidates[2]. During reperfusion there may be catastrophic consequences in the presence of an intracardiac shunt, as hypoxemia can occur due to the combination of increased PVR and decreased SVR leading to a right-to-left shunt. With the shunt reversal, air and debris can cross over to systemic circulation causing paradoxical embolization.

We report the case of a patient who presented for an urgent donation after cardiac death (DCD) OLT in whom preoperative transthoracic echocardiography (TTE) discovered the presence of a ventricular septal defect (VSD).

CASE PRESENTATION

Chief complaints

The chief complaints are not applicable.

History of present illness

A 43-year-old male with end-stage liver disease secondary to primary sclerosing cholangitis with a sodium–MELD of 19 presented for an urgent OLT. He had features of portal hypertension and had exception points due to the development of hepato-

cellular carcinoma. Routine preoperative investigations included a TTE performed eleven months before the surgery which was reported as normal.

History of past illness

The history of past illness is not applicable.

Personal and family history

The personal and family history is not applicable.

Physical examination

The physical examination is not applicable.

Laboratory examinations

The laboratory examinations are not applicable.

Imaging examinations

A bedside TTE performed immediately before the procedure identified the presence of abnormal flow in the right ventricular (RV) outflow tract on the parasternal long-axis view and RV parasternal inflow-outflow view. The patient then mentioned that he had a VSD in childhood which had closed spontaneously. This information was missed in all prior interactions between the patient and the multidisciplinary transplant team.

Further examination demonstrated a single jet with left-to-right shunt across the interventricular septum on the apical 4 chamber view, suggestive of a perimembranous VSD (Figure 1). Significant pulmonary hypertension was ruled out with an estimated RV systolic pressure (RVSP) of 25-30 mmHg by the tricuspid regurgitation jet, considering a CVP of 10 mmHg.

Our findings were discussed with the patient and the surgical team with the consensus to proceed with the surgery due to the time sensitive nature of the DCD graft. We then devised an intraoperative plan of optimizing the pulmonary and systemic pressures using vasoactive support and the most appropriate mode of mechanical ventilation for this case. We monitored changes in the magnitude of the shunt with intraoperative transesophageal echocardiography (TEE).

After induction of general anesthesia, TEE showed a shunt fraction (Q_p:Q_s) of 1.1 and flow velocity across the VSD of 4.5-5 m/s (Figures 2 and 3A) with no indirect signs of volume or pressure overload to the RV. During the procedure, the pressure controlled ventilation mode was used with an inspiratory to expiratory (I:E) ratio of 1:3 to reduce the peak and mean airway pressures. We aimed for hyperventilation ($ETCO_2$ < 25-30 mmHg) and hyperoxia (FiO_2 > 70%) in an attempt to minimize the pulmonary vascular resistance, whilst continuously monitoring the flows through the VSD for shunt reversal.

After release of the inferior vena cava clamp, considerable turbulent flows with air were noted in the RV, but no air was visualized in the left ventricle (LV) (Figure 3B). Systemic hypotension occurred, and velocity across the VSD reduced to 2.5 m/s, but the shunt did not reverse (Figure 3C). Using the LV systolic blood pressure (LVSP) of 80 mmHg at that moment, we estimated a RVSP of 55 mmHg using the hemodynamic calculation of LVSP-RVSP = 4 (VSD velocity)^2. Vasopressin was the vasopressor of choice to treat the hemodynamic instability as it has a differential effect on the pulmonary and systemic circulation, increasing the SVR more than the PVR. At the end of the procedure, the patient was extubated in the operating room, and transferred to the intensive care unit.

FINAL DIAGNOSIS

The final diagnosis of the case presented is a perimembranous VSD in an OLT recipient.

TREATMENT

The patient's VSD was small and the shunt fraction did not warrant closure of the VSD pretransplant. Intraoperatively we managed the hemodynamics of the patient to minimize the fluctuation in the shunt direction.

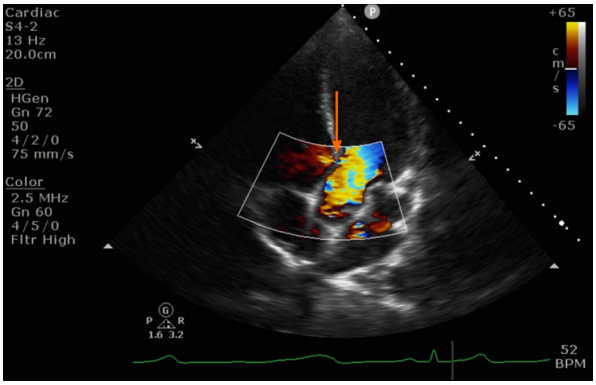

Figure 1 Transthoracic echocardiography apical 4 chamber view showing a small peri membranous ventricular septal defect with a left to right shunt (orange arrow).

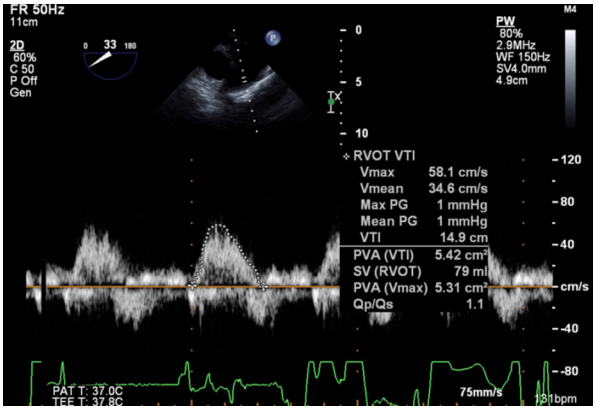

Figure 2 Continuity equation to calculate shunt fraction Qp:Qs using transesophageal echocardiography.

OUTCOME AND FOLLOW-UP

The patient's postoperative clinical course was complicated by non-cardiac musculoskeletal chest and arm pain which were unrelated to the ventricular septal defect. It resolved with appropriate management and the patient was discharged home 10 d following surgery. We had advised the patient to follow up with a cardiologist due to the persistent finding of congenital VSD.

DISCUSSION

To our knowledge, this is the first report in the literature of a patient with an undiagnosed VSD undergoing an OLT. An increased risk of embolic events in patients with a patent foramen ovale during OLT has already been described[3]. In addition, a retrospective study of patients undergoing liver transplants showed that intracardiac shunts were not associated with an increased risk of perioperative stroke[4].

Since our patient's VSD was diagnosed immediately prior to surgery, a time-dependent, critical decision had to be made of whether to proceed with the transplant or postpone the surgery and refer the patient to a cardiologist. AHA/ACC guidelines show that small restrictive VSDs are managed clinically, and surgical interventions are indicated in VSDs with a Qp:Qs ratio greater than 1.5 or if there is prolapse of an aortic valve cusp into the VSD causing progressive aortic regurgitation[5]. None of these features were present in our patient and after a discussion involving the anesthesia team, surgical team, and the patient, we decided to proceed. It was suggested to use intraoperative TEE to guide hemodynamic management and to monitor the shunt direction for risk of paradoxical embolism.

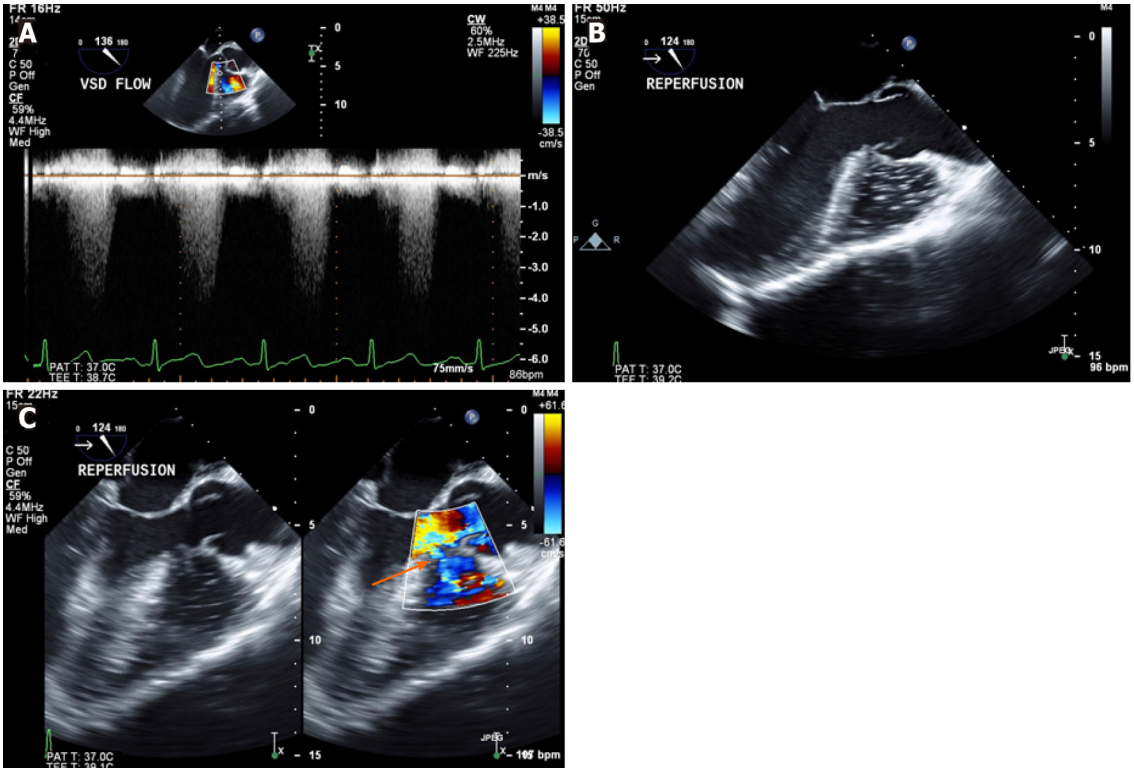

Figure 3 Transesophageal echocardiography mid esophageal long axis view. A: Continuous wave doppler to calculate shunt flow velocity across the ventricular septal defect; B: Air/debris from newly implanted liver in the right ventricle only; C: Unchanged direction of left to right shunt (orange arrow) post reperfusion.

CONCLUSION

Our case highlights the importance of performing a bedside focused TTE exam immediately before the OLT procedure, and this has become standard practice at our center. Patients might be on the transplant list for a substantial length of time before a suitable deceased donor organ is available, and cardiac diseases may have progressed or developed in the interim. Furthermore, as anesthesiologists, we understand intraoperative nuances and the impact of significant findings on hemodynamic management.

Another important aspect is the use of intraoperative TEE in OLT, which has become common practice amongst transplant centers. Whether its use in our case, along with additional intraoperative management techniques (goal-directed management of PVR and SVR to avoid reversal of the shunt by optimization of ventilatory parameters and vasoactive drugs during reperfusion), have led us to a positive outcome or not can be questionable. However, having a tool to modify our surgical management using real time images during the critical phases of liver transplant allows us to provide optimal patient care.

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Contents

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Retrospective Study

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Contents

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Editorial Board Member of *World Journal of Anesthesiology*, Kar-Lok Wong, MD, PhD, Academic Fellow, Director, Doctor, Full Professor, Department of Anesthesia, China Medical University and Hospital, Taichung 40000, Taiwan. kalwong1268@gmail.com

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ORIGINAL ARTICLE

Retrospective Study

Pre-formed endotracheal tube and stepwise insertion for more successful intubation with video laryngoscopy

Ahmed A Shorrab, Moustafa A Helal

ORCID number: Ahmed A Shorrab 0000-0003-3243-114X; Moustafa A Helal 0000-0001-5226-9472.

Author contributions: Shorrab AA designed the study, analyzed the data, and wrote the manuscript; Helal MA co-conducted the clinical portion of the study, collected the patients' clinical data, and revised the manuscript and references.

Institutional review board statement: This study was approved by the Ethics and Research Committee of University Hospital Sharjah, No. UHS-HERC-014-30072019.

Informed consent statement: All patients who participated in the study provided informed consent and underwent general anesthesia with orotracheal intubation.

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Ahmed A Shorrab, Department of Anesthesia, University Hospital Sharjah, Sharjah POB 72772, United Arab Emirates

Ahmed A Shorrab, Moustafa A Helal, Faculty of Medicine, Mansoura University, Mansoura 35516, Egypt

Moustafa A Helal, University Hospital Sharjah, Sharjah, United Arab Emirates

Corresponding author: Ahmed A Shorrab, Senior Consultant of Anesthesia, Department of Anesthesia, University Hospital Sharjah, University City Road Near Matajer Al Juraina, Sharjah POB 72772, United Arab Emirates. ahmed.shorrab@uhs.ae

Abstract

BACKGROUND

In anesthesia practice, orotracheal intubation remains the primary concern of the anesthesiologist. The introduction of video laryngoscopy (VL) has increased the success rate of orotracheal intubation; however, conflicting results have been reported regarding the usefulness of the current technique with VL in clinical practice.

AIM

To describe a modification to improve intubation with VL, followed by evaluation of the practice *in vivo*.

METHODS

First, a mannequin trial was conducted with operators having different experience and background. Then, a retrospective analysis was performed for an > 1-year period with patients who underwent general anesthesia with orotracheal intubation. The endotracheal tube used had been pre-formed with two curves. Stepwise intubation had been performed with direct eye vision, followed by screen assistance and rotation of the tube as needed to direct it toward the glottis. In the mannequin trial, the outcome measures were quantification of torque (force with angular acceleration during levering), need for external maneuvers, and time to intubate. In the clinical experience, orotracheal intubation used VL (pre-formed tube) or direct laryngoscopy (DL) at the anesthetist's discretion and throat discomfort was reported by the patient.

RESULTS

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Grade E (Poor): 0

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In the mannequin trials using VL, there was less torque with the pre-formed tube than with a regular tube (8% and 65%, respectively). The first-pass rate was higher with the pre-formed tube (95%) than with a regular tube (81%). However, the time to intubate was longer with the pre-formed tube than with a regular tube (22 s and 12 s, respectively). In clinical practice, 562 patients underwent surgery under general anesthesia with orotracheal intubation using either VL (n = 244) or DL (n = 318) at the discretion of the attending anesthetist. VL was specifically planned in 62 of the patients, due to anticipated difficulty. Second attempts by readjustment of the curve of the tube were significantly fewer with VL than with DL (10% *vs* 18%). Throat discomfort was reported by fewer patients who underwent VL than those who underwent DL (6% *vs* 24%).

CONCLUSION

Pre-formed endotracheal tube with stepwise insertion produces less torque, fewer external maneuvers and higher first-pass success rate during VL intubation. Further, prospective studies are warranted.

Key Words: Intubation; Glottis view; Airway; Indirect laryngoscopy; Torque

Core Tip: Video laryngoscopy (VL) is gaining popularity in the practice of endotracheal intubation. Failure of VL-assisted intubation may be attributed to the fact that practitioners use the same technique employed for traditional rigid laryngoscopy. We describe a technique based on pre-forming the endotracheal tube with two specific curves and using a stepwise insertion technique to facilitate the VL and achieve a higher success rate. The tool was tested in a mannequin trial first and then applied to clinical practice. The first-pass success rate was higher, with minimal torque and fewer external maneuvers required.

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INTRODUCTION

Successful tracheal intubation remains a major concern in anesthesia practice. Failure to intubate the trachea may be associated with serious complications, such as pulmonary aspiration and difficult mask ventilation, which may result in life-threatening hypoxia. Furthermore, repeated attempts at intubation may damage the upper airway and make mask ventilation more difficult. In fact, difficulty in tracheal intubation is the most common cause of serious airway complications during anesthesia[1]. The use of rigid indirect optical laryngoscopes, or "video laryngoscopes," has attracted increasing interest. Aziz *et al*[2] suggested the usefulness of a video laryngoscope in patients with predicted difficult tracheal intubation, and Fiadjoe *et al*[3] documented the efficacy of another video laryn-goscope in infants. During the era of coronavirus disease 2019 (commonly known as COVID-19) pandemic, video laryngoscopy (VL) is recommended to minimize the risk of contamination in anesthesia and intensive care practice[4,5].

However, despite VL providing adequate visualization of the larynx, difficulty in intubation and longer intubation times have been reported[1,6,7]. Attempts at improving the curve of the blade or manipulating the stylet as a lever to the epiglottis have been described[8]. We believe that one reason for longer times or intubation failures is that the practitioner uses the same strategy as in direct laryngoscopy (DL). The technical difficulty may be attributed to the fact that the vision axis obtained by the camera at the tip of the blade is usually different from the axis of the tracheal tube. Moreover, the tracheal tube itself and its cuff may obscure the glottis view because of the camera's short-sight of the larynx and glottis.

In this study, we aimed to evaluate a new technique for improving the success rate of VL intubation. The technique includes a pre-formed tracheal tube for which a stepwise insertion technique is employed.

MATERIALS AND METHODS

The study protocol was approved by the Ethics and Research Committee of University Hospital Sharjah (No. UHS-HERC-014-30072019). It was designed to describe a modification to improve intubation with VL followed by evaluation of its application in practice (*in vivo*). All patients who participated in the study provided informed consent and underwent general anesthesia for orotracheal intubation (see Video at: https://drive.google.com/file/d/1AWJubzMF6o0as4r9rVbncq2H-QZ1Twr_/view?usp=sharing).

Pre-forming the tracheal tube

Two bends were created in the endotracheal tube, with the stylet in place. The first bend was made at the distal third, at 30° relative to the existing curve of the tube. The second bend was made between the middle and proximal thirds, at 30° clockwise. For adult applications, the two bends were located at approximately 9 cm and 18 cm, as shown in Figure 1.

Stepwise insertion of the tube

Step 1: Blade insertion, down to the base of the tongue, performed without looking at the video monitor screen (Figure 2).

Step 2: Tube insertion, at the right corner of the mouth, to pass the pillars under direct vision and performed without looking at the video monitor screen; the distal angle is facing the angle of the mouth (Figure 3).

Step 3: Looking at the video monitor screen, the laryngoscope blade is advanced down to the epiglottis; then, gently passing the tube with counterclockwise rotation, as needed to intubate (Figure 4).

Step 4: As the tip of the tube passes the vocal cords, the stylet is removed with a gentle counter push to pass the cuff below the vocal cords.

The technique was first practiced by multiple operators on a mannequin and subsequently performed in clinical practice. In the mannequin trials, the outcome measures were quantification of torque, need for external maneuvers, and time to intubate. In clinical practice, the outcome measures were need for a second attempt and postoperative throat discomfort reported by the patients (data retrieved from patient records).

Mannequin trials

A commercially-available mannequin created for airway management (Laerdal® Airway Management Trainer; Laerdal Medical, Stavanger, Norway) and a C-MAC® video laryngoscope (Karl Storz SE & Co. KG, Tuttlingen, Germany) was used to practice the technique. A size-3 blade was used in both attempts. Twenty providers with varying experience levels and backgrounds in airway management (*i.e.*, anesthesiologist, intensivist, and anesthesia technician) practiced the technique. The intubation method was explained and demonstrated by the 1st author (Shorrab AA), followed by hands-on practice by the participants. Then, for the study purpose, each participant performed three intubations with VL using a regular tube and three intubations with the pre-formed tube. The time to successful intubation and torque were recorded. Torque, defined as a force accompanied with angular acceleration during arm levering, was signified by a clicking sound coming from the joint articulating the jaw and head to the neck of the mannequin. The sound is audible when the force exceeds 8 pounds per square inch.

Clinical practice application

All cases scheduled for general anesthesia with endotracheal intubation over the year of 2019 were retrospectively analyzed. A total of 618 records were examined, of which 56 (9%) were excluded due to incomplete airway management documentation. The choice of airway management with either DL or VL had been made at the anesthetist's discretion without prior randomization. The new VL technique had been employed in

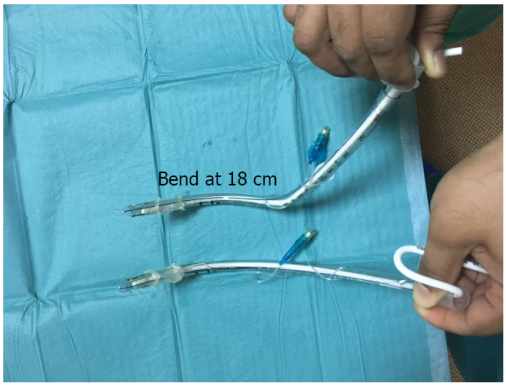

Figure 1 Regular tube (lower) and pre-formed tube (upper) with one bend at 9 cm and 30° from the horizontal plane (natural curve) and a second bend at 18 cm and at 30° right to the vertical plane.

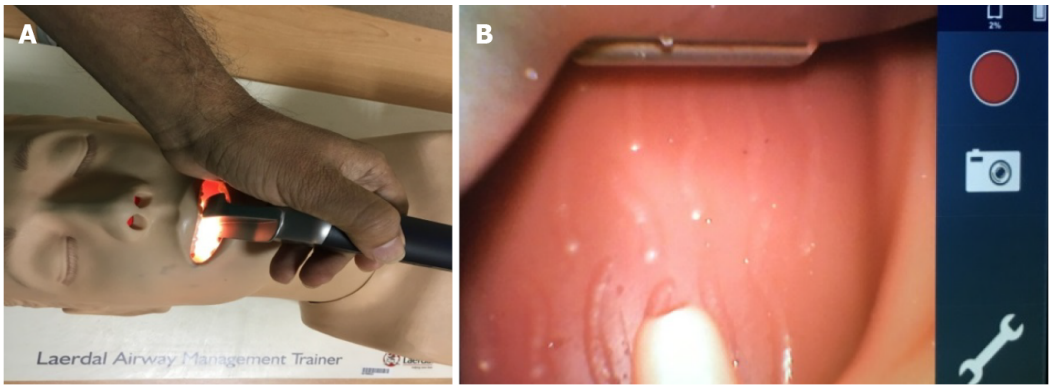

Figure 2 Passing the blade to the oropharynx. A: Direct eye vision; B: Video monitoring screen.

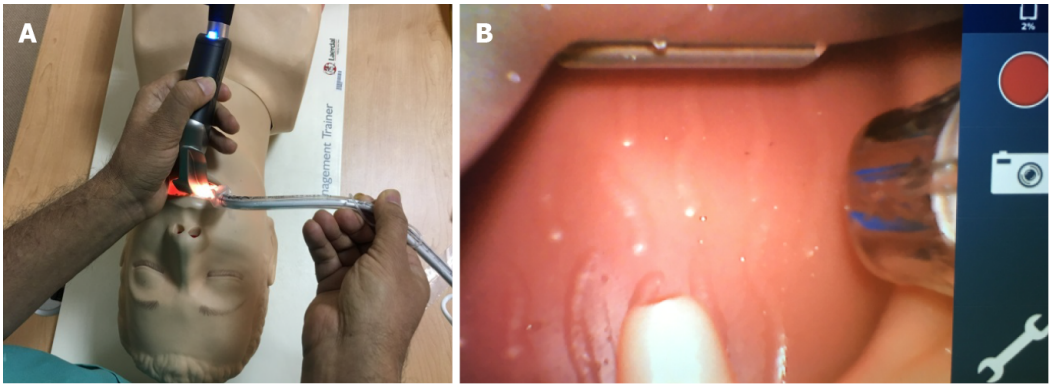

Figure 3 Passing the tube through the right angle of the mouth to pass the tonsillar pillars. A: Under direct eye vision; B: Then, by looking at the video monitoring screen for further advancement.

daily routine in patients with different demographic characteristics. The need for a second attempt at intubation had been recorded. Postoperative throat discomfort (reported by the patients) had also been recorded.

Statistical analysis

Because the clinical study was a retrospective, descriptive study covering almost 1 year of practice, the sample size had not been determined a priori. Considering that the new technique would increase the intubation rate success of 75% reported in the MACMAN trial[9] to 90%, setting the type I error at 5% and the type II error at 10%, the sample size of 562 patients collected over the study period was considered sufficient for meaningful statistics.

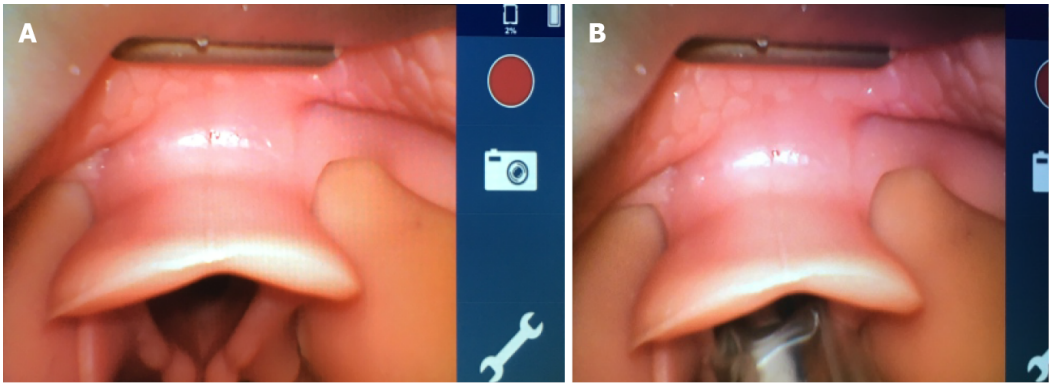

Figure 4 Advancing the blade to see the glottis (A), then advancing the tube with slow counterclockwise rotation to pass through the glottis (B), and finally removing the stylet under video monitoring screen guidance.

Categorical data were expressed as numbers and percentages, and continuous data were expressed as averages and ranges. Binary data were analyzed using a test for two proportions (Fisher's exact test). Continuous data were analyzed using a two-sample *t*-test. An online calculator (https://statskingdom.com) was used for the analysis[10]. A *P* value of less than 0.05 was considered statistically significant.

RESULTS

In the mannequin trials, the time to intubate was longer with the pre-formed tube than with a regular tube. The first-pass success rate was higher with the pre-formed tube than with a conventional tube. More torque was exerted with DL than with VL (Table 1).

For the application in clinical practice, VL with the pre-formed tube was performed in 244 patients; in 62 of these patients, the VL had been specifically planned due to anticipated difficult intubation (Table 2). Second attempts by readjustment of the curve of the tube were significantly fewer with VL than with DL. Throat pain was reported by significantly fewer patients in the VL group than in the DL group (Table 3).

DISCUSSION

With VL, the "can see the glottis but cannot intubate" scenario is still encountered. Challenges in the use of VL have been described, including the moment when the position of the tip of the tube cannot be confirmed during its insertion due to obscuration of the vision axis. Therefore, even when a clear view of the glottis is obtained on a video monitoring screen, it can often be difficult to direct the tube towards it, and the upper airway may be traumatized in this blind moment[1,2]. One reason for this is that practitioners are used to employing the same technical strategy used for DL.

During the practice on a mannequin, less torque was used with the pre-formed tube, as compared to that used with the conventional tube. The laryngoscopist who experiences difficulty will use more force, and torque will appear[11]. Direct stimulation of the extensively innervated oropharynx by the laryngoscope blade will increase the hemodynamic changes[12,13]. Excessive force and torque applied during DL will be associated with inadvertent damage to the teeth, oral cavity, and/or oropharynx[14,15].

The pre-formed tube with two curves described in this study proved to be efficient, in terms of both ease and intubation success with less torque. It has previously been reported that the C-MAC video laryngoscope provides a comparable or better glottic view than DL[16]. Strategies for enhancing the glottis view have also been described [17]; however, a good glottic view does not necessarily translate into greater intubation success. With our tool, the passage of the tube from the right lateral angle of the mouth offers room for better visualization, without obstructing the field of view. The double curves allow counterclockwise rotation and up-and-down movement of the tube tip, as required to reach the glottis. In patients with a non-visualized or partially

Table 1 Video laryngoscopy performed on a mannequin with a pre-formed *vs* a conventional endotracheal tube

Outcome measures	Pre-formed tube	Conventional tube	*P* value
Intubations, *n*	60	60	
Time to intubate in s, average (range)	22 (15-42)	12 (7-15)	0.008[a]
First-pass success, *n* (%)	57 (95)	49 (81)	0.03[a]
Torque > 8 PSI, *n* (%)	5 (8)	39 (65)	0.001[a]

[a]*P* < 0.05. PSI: Pounds per inch.

Table 2 Indications for specifically planned video laryngoscopy

Indication	*n*
Mallampati 4	9
Micrognathia/receding mandible	8
Macroglossia	4
Abnormal dentation	10
Trisomy	3
Neck collar	3
Neck contracture	2
Neck osteoarthritis	16
BMI > 45	6
Hemiglossectomy	1
Total	62

BMI: Body mass index.

Table 3 Comparison between video laryngoscopy using a pre-formed tube and direct laryngoscopy

	VL with pre-formed tube	DL	*P* value
Patients, *n* (%)	244 (41)	318 (59)	
Second attempts, *n* (%)	25 (10)	57 (18)	0.02[a]
Throat pain, *n* (%)	14 (6)	78 (24)	0.009[a]

[a]*P* < 0.05. DL: Direct laryngoscopy; VL: Video laryngoscopy.

visualized glottis opening, the styleted tube allows the anesthetist to lever the epiglottis with the distal tip of the tube, without the need for neck extension and with the least possible torque/force.

Our technique introduces a new way of using VL, including a pre-formed tube and a stepwise application to overcome the difficulties encountered in VL. Aziz *et al*[2] found that failure to intubate the trachea, despite achieving an adequate laryngeal view, occurred at a similar frequency with the C-MAC and with DL. In addition, VL is reported to have limited success and possible risks in both anesthetic[18] and intensive care[9,19] practices. The reason for first-pass endotracheal intubation failure is likely the difficulty in aligning the endotracheal tube with the orotracheal axis determined by the camera on the blade of the laryngoscope.

In our study, the time to intubate was significantly longer with VL than with DL. This is attributed to the careful insertion carried out in two stages: First, direct eye visualization, followed by video monitoring screen visualization. Additionally, the careful rotation of the tube during advancement increases the time to intubate. The time requested for intubation with the pre-formed tube was longer than that with the

conventional tube. This may not be ideal during rapid sequence induction. However, it is useful in difficult scenarios, where adequate pre-oxygenation can ensure normoxia throughout the intubation period. However, none of the patients in our study were desaturated during intubation. Previous studies on VL have reported slightly longer intubation times compared with DL[2,20]. Moreover, as the practitioner progresses along the learning curve, the time to intubate is expected to become shorter.

With our technique in clinical practice, the rate of second attempts was approximately 10%, which was significantly lower than that with DL (18%). Previous studies have reported fewer external maneuvers required and less frequent need for a bougie with VL than with DL[2,21].

In practice, patient feedback on anesthesia experience includes the report of throat discomfort. In our study, significantly fewer patients reported throat discomfort with VL than with DL. The less torque and the stepwise insertion of the tube under direct vision followed by screen guidance may have caused a milder trauma to the oropharyngeal structures, resulting in less throat discomfort. Less force during intubation with VL than with DL practiced on mannequins by operators with varying experience has also been reported[22]. Therefore, we speculate that throat discomfort, stress during intubation, and cardiovascular responses are less severe with our technique.

In this cohort, VL was planned for 62 patients due to anticipated difficulty in airway management. We opted for VL in cases of difficult intubation based on previous reported experiences[23,24] and on the encouraging results of our mannequin trials.

A limitation of our study is that it was neither randomized nor blinded. The airway management decision was made at the anesthesia providers' discretion, except in patients with expected difficulty, for whom VL was planned for safety reasons. However, the personnel collecting the data were not involved in the procedure. Another limitation is that the clinical portion of our study was not prospective, which would have allowed for comparison of the pre-formed and conventional endotracheal tube during VL. The underlying reason for this was that we considered an ethical obligation to apply the best practice of intubation to patients, without subjecting them to randomization. One more potential limitation is interoperator variability. However, including operators with various experience levels and backgrounds might mimic the real-world practice of airway management. In this study, comparisons between the traditional VL technique and the new VL technique concerned only the mannequin trials, whereas in clinical practice, the new VL technique was compared to DL, not to the conventional VL technique. Future randomized studies could be conducted on VL to compare the proposed technique to the conventional one.

CONCLUSION

In conclusion, the use of a pre-formed endotracheal tube and a combination of direct vision and video monitoring screen guidance, with careful rotation of the tracheal tube, is associated with less torque and fewer external maneuvers. The technique carries potential for a higher first-pass success rate and less postoperative throat discomfort. VL requires special tactics, however, different from those used in DL, and may warrant training and orientation. Prospective studies are also warranted.

ARTICLE HIGHLIGHTS

Research background

Despite the wide use of video laryngoscopy (VL) for intubation, conflicting results have been reported regarding its usefulness. A new technique was introduced with the aim of improving the success rate of VL intubation. This technique includes pre-forming the tracheal tube, followed by a stepwise insertion process during VL intubation.

Research motivation

The "can see but can't intubate" scenario is frequently reported during intubation with VL. We believe that the new technique will provide room for better manipulation of the tracheal tube, providing higher first pass rate and allowing for use of less force. In the future, a pre-formed tube with memory to negotiate for intubation could be introduced for more convenient and successful practice.

Research objectives

The objective of the study was to increase the success of intubation during VL.

Research methods

First, a mannequin trial was conducted with operators having different experience levels and backgrounds. Then, a retrospective analysis was performed for an > 1-year period with patients who underwent general anesthesia with orotracheal intubation. The endotracheal tube used had been pre-formed with two curves, which was then applied in a stepwise intubation process with direct eye vision, followed by screen assistance to direct it toward the glottis. In the mannequin trial, the outcome measures were quantification of torque (force with angular acceleration during levering), need for external maneuvers, and time to intubate. In the clinical experience, orotracheal intubation used VL (pre-formed tube) or direct laryngoscopy (DL) at the anesthetist's discretion, and throat discomfort was reported by the patient.

Research results

In the mannequin trials using VL, there was less torque required and a higher first pass rate achieved with the pre-formed tube than with a regular tube. In clinical practice, second attempts by readjustment of the curve of the tube were significantly fewer with VL than with DL, and throat discomfort was reported by fewer patients who underwent VL.

Research conclusions

The use of a pre-formed endotracheal tube and a combination of direct vision and video monitoring screen guidance, with careful rotation of the tracheal tube, is associated with less torque and fewer external maneuvers. The technique carries potential for a higher first-pass success rate and less postoperative throat discomfort. Nonetheless, VL requires special tactics and may warrant training and orientation.

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