General Anesthesia Management for Adult Mucopolysaccharidosis Patients Undergoing Major Spine Surgery

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Significance of the Study

- Anesthesia for adults with mucopolysaccharidosis undergoing major surgery is challenging because of upper airway deformities and cardiac dysfunction.
- Observations from this case series describing complex airway management and cardiac complications will alert anesthesia providers to potential complexities.

Keywords

Airway management · General anesthesia · Mucopolysaccharidosis · Spine surgery · Fiberoptic intubation · Video-laryngoscope

Abstract

Objective: Mucopolysaccharidosis (MPS) are a group of rare systemic lysosomal storage diseases associated with severe airway obstruction and cardiac disease, making anesthesia management difficult. Contemporary treatment extends the lifespan of affected individuals, increasing the need for major surgery in adulthood. **Clinical Presentation and Intervention:** We provided general anesthesia for 6 adult MPS patients undergoing spine surgery. The airway was assessed as difficult in all, with 2 receiving awake fiberoptic intubation and 1 successfully undergoing video-laryngoscopy, while 3 video-laryngoscopy procedures failed and required conver-

sion to fiberoptic intubation. One patient developed ventricular fibrillation. **Conclusion:** Adult MPS patients have substantial anesthesia risk.

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Published by S. Karger AG, Basel

Introduction

Mucopolysaccharidosis (MPS) are a group of rare inherited lysosomal storage diseases resulting from defects in lysosomal enzymes involved in degradation of glycosaminoglycans, known as mucopolysaccharides [1]. Such enzyme deficiency results in accumulation of partially degraded glycosaminoglycans in lysosomes in various tissues and organs, leading to development of respective systemic dysfunctions, and several clinical types, termed MPS I, II, III, IV, VI, VII, and IX, have been identified [1, 2].

Table 1. Characteristics of MPS patients who underwent supine surgery, including airway management and intraoperative complications

No.	Age, years	Height, cm/weight, kg	MPS type	Enzyme therapy	Cardiac function		MR	AR	Surgical characteristics			Tracheal intubation			time, min	SpO ₂ high/low
					LV function	RV function			type of surgery	time, min	bleeding, mL	status	mask	intubation		
1	28	126/34	I	+	Restrictive cardiomyopathy		mild	mild	Scoliosis correction	408	420	Awake	Not done	FOB-I	13	100/99
2	38	149/60	II	+	Normal		trivial	mild	Cervical decompression	219	140	Awake	Not done	FOB-I	18	100/96
3	37	145/48	II	+	Nearly normal		trivial	mild	Cervical decompression	177	270	Under anesthesia	Easy	VL success	8	100/99
4	20	145/45	I	+	Nearly normal		mild	mild	Cervical decompression	204	120	Under anesthesia	Easy	VL failure-success with FOB-I	9	100/99
5	13	155/49	II	+	Normal		mild	moderate	Cervical decompression	247	250	Under anesthesia	Rather difficult	VL failure-success with FOB-I	10	100/97
6	20	156/49	VII	-	Normal		none	none	Cervical decompression	261	240	Under anesthesia	Rather difficult	VL failure-success with FOB-I	12	100/94

During the operation, patient No. 1 developed ventricular tachycardia and subsequent ventricular fibrillation (see details in the text). All patients were extubated at the end of surgery, except for No. 1 and 6, who were extubated the next morning. A cuff leak test to check for air leakage around the tracheal tube by cuff deflation was performed prior to extubation in all patients, and none exhibited airway edema or severe obstruction upon extubation. AR, aortic regurgitation; FOB-I, fiberoptic bronchoscope intubation; LV, left ventricle; MPS, mucopolysaccharidoses; MR, mitral regurgitation; SpO₂ high/low, highest and lowest values for percutaneous arterial oxygen saturation during intubation; Time (intubation), time from start of anesthesia to completion of intubation; VL, video-laryngoscope intubation.

Formerly, the typical lifespan of an MPS patient was 10–20 years, with mortality due to advancing respiratory complications and/or cardiac insufficiency. However, recently implemented bone marrow transplantation and enzyme replacement therapies targeted to alleviate enzyme deficiency seem to have extended longevity [3–5]. Importantly, these patients often suffer from scoliosis and spinal cord compression, which may require complex surgical treatments [6].

MPS patients have elevated risk for anesthesia-related complications [1, 2]. Specifically, glycosaminoglycans accumulate in connective tissues of the oropharynx and airway, leading to airway obstruction, which can present great difficulty with airway management. Furthermore, a concomitant unstable atlantoaxial joint may restrict cervical extension [6], a maneuver essential for mask ventilation and successful tracheal intubation. Accumulation of glycosaminoglycans in cardiac tissue leads to valvular abnormalities and cardiac insufficiency, coupled with diastolic dysfunction [7, 8].

Although such difficulties in infant cases have been emphasized [1, 2], anesthesia for adult MPS patients undergoing major spine surgery is also challenging, though case reports have rarely been presented [2]. The Osaka City University Hospital is a high-volume center for spine surgery as well as a core center for treatment of individuals affected by MPS. During the past decade, we have provided general anesthesia for 6 adult MPS patients who underwent spine surgery. The present is a retrospective report of anesthesia management for these patients.

Case Report

Six MPS patients (2 MPS I, 3 MPS II, and 1 MPS VII) underwent surgery with general anesthesia, 5 for cervical decompression and 1 for correction of scoliosis (Table 1). Informed consent was obtained from each or their guardians for publication of clinical findings, including images and photos.

Preoperative Physical Condition

All patients were shorter than average for their age and extremity disabilities were noted, such as clumsiness, abnormal gate, and limb weakness, as well as characteristic facial features including a short neck with limited mobility, and inability to fully open the mouth coupled with macroglossia and plump lips (Fig. 1a–c). Cervical spine disorder was another characteristic presentation (Fig. 1d).

Laryngeal Findings

Fiberscope examinations revealed abnormal enlargement of the epiglottis, arytenoid region, and false vocal cords (Fig. 2), with the epiglottis forming an omega shape in some. These changes

Fig. 1. **a–c** External appearance of MPS patients. **a** Typical full-length photograph of a representative adult MPS II patient, with a shortened stature and short neck, as well as deformity and disability of the extremities. **b, c** Typical facial features of representative MPS I (**b**) and II (**c**) patients, each of whom had difficulty in fully opening the mouth because of macroglossia and plump lips. **d** MR image of cervical spine. Sagittal T2-weighted MR image of the cervical spine of representative adult MPS II patient. Physiological spine curvature had disappeared, while the cervical vertebrae were hypoplastic. The spinal cord was compressed throughout the cervical spine, especially in the upper cervical region, with pathological enlargement of the posterior region of the odontoid process. T2 hyperintensity in the C2–3 spinal cord parenchyma area was noted, indicating a pathological change of the spinal cord due to compression.

produced a long narrow pseudo-tunnel to the glottis, which disturbed direct visualization of the glottis for tracheal intubation. However, none of the patients showed severe vulnerability of the oropharyngeal structure. Consistent with these findings, no patient had clinical manifestations causing severe obstructive sleep apnea or other airway obstruction.

Respiratory Management

No premedication including sedatives and anticholinergics was given to any of the patients. An intravenous drip line was established in the nondominant arm before starting anesthesia. Awake oral intubation using a fiberoptic bronchoscope was considered in 2 patients, due to severe spinal cord compression in 1 and reduced mouth opening in the other (Table 1). Intubation in both was performed under oxygen insufflation with remifentanyl at 0.05–0.15 µg/kg/min, with lidocaine applied to the larynx and respiratory tract as topical anesthesia. In the other 4 patients, anesthesia was carefully induced with propofol, sevoflurane, and rocuronium bromide. Mask ventilation was successfully performed in each, though a 2-handed method was required. First, tracheal intubation was attempted with use of a video-laryngoscope (McGRATH® MAC; Medtronic, Tokyo). In 1 patient, tracheal intubation using a McGRATH® MAC equipped with an X3 blade, an acutely curved special blade designed for difficult airways, was successfully performed. In the other 3 cases, a standard blade was used and only the epiglottis could be visualized, thus fiberoptic intuba-

tion was employed, indicating that it was superior for tracheal intubation as compared to video-laryngoscopy in our MPS patients. Tracheal intubation was performed within 18 min in all 6 patients without a significant decrease in arterial oxygen saturation.

At the end of surgery, 4 patients underwent uneventful tracheal extubation, while 2 were extubated the next morning; 1 due to extended surgical time and the other to intraoperative onset of ventricular fibrillation related to massive intraoperative hemorrhage.

Circulatory Management

In preoperative findings, 5 patients showed nearly normal cardiac function, while the other received cardiac therapy with digoxin, furosemide, and mexiletine due to mildly reduced cardiac function along with diastolic dysfunction. In that patient, who demonstrated restrictive cardiomyopathy, a massive hemorrhage occurred during surgery, resulting in ventricular tachycardia, triggered by a premature complex, i.e., R on T phenomenon (Fig. 3). Since the patient had a very limited tolerable range for circulating volume related to the restrictive cardiomyopathy, fluid resuscitation with blood replacement for the hemorrhage might have induced circulatory overload leading to cardiac failure. Pathological prolongation of the corrected QT interval (520 ms) may have also contributed to ventricular fibrillation. Severe arrhythmia and circulatory insufficiency were treated with defibrillation and subsequent catecholamine therapy. In the other patients, there were no serious perioperative hemodynamic events.

Discussion

The present findings show that when dealing with an adult MPS patient, anesthesiologists must be prepared for management of a difficult airway and have different airway adjuncts available for use. Since even contemporary video-laryngoscopy techniques may not be sufficient for successful tracheal intubation in these cases, fiberoptic equipment should be readily employable in all cases, while participation by more than a single anesthesiologist is desirable, as these patients may be difficult to ventilate with a mask. Furthermore, when severe difficulty with mask ventilation is encountered, a supraglottic airway device or rescue reversal by use of a muscle relaxant such as sugammadex should be considered as part of an alternate method. Notably, a supraglottic airway may be a good option for management of a difficult airway in MPS patients [9]. In addition to airway consideration, cardiac status must be thoroughly reviewed, because potential dysrhythmias or dysfunction in those with altered cardiac function should be anticipated. Although few studies are available regarding anesthesia for adult MPS patients like our cases, fiberoptic intubation was reported to be employed with success in most cases, while cardiac events did not develop [2].

Fig. 2. Internal views of the larynx. **a–f** Fiberscope images showing the internal view of the larynx in 6 MPS patients. Pathological enlargement of the epiglottis, false vocal cords, or arytenoid region were observed in these patients. Deformity and vulnerability of the larynx caused airway obstruction and difficulty with tracheal intubation. ar, enlarged arytenoid region; e, enlarged epiglottis; fvc, enlarged false vocal cord; oe, inverted u-shaped or omega-shaped enlarged epiglottis. **g** Fiberoptic intubation view. Frame view obtained during fiberoptic intubation performed in the patient shown in **b**, with typical enlarged omega-shaped epiglottis.

Fig. 3. Ventricular tachycardia in patient No. 1 noted in Table 1. **a** During scoliosis correction surgery, ventricular tachycardia was triggered by a premature complex on the T wave (R on T, indicated by an arrow), which developed just after a massive hemorrhage, and subsequent intravenous fluid and blood replacement therapy. Arterial systolic blood pressure, measured using a radial artery catheter, suddenly decreased (<50 mm Hg). Prior to R on T development, the corrected QT interval was prolonged by 520 ms. **b** Soon thereafter, ventricular tachycardia changed to ventricular fibrillation.

Recently, bone marrow transplantation and enzyme replacement therapies have been shown to result in removal of pathologically accumulated glycosaminoglycans, possible direct contributors to mortality, thus improving airway obstruction and cardiac function [3–5]. However, because of poor perfusion of organs or tissues, such as bone, heart valve, and cornea, as well as some areas of the central nervous system, protected by the blood brain barrier, those do not generally respond to such therapeutic modalities. Thus, MPS-related bone deformity, especially in the spinal region [5, 6], as well as cardiomyopathy related to valvular dysfunction [7, 8] slowly advance with age. Since spinal disorders show the most serious deterioration, adults with MPS may frequently require a surgical procedure for the spine [5, 6], though that is typically extensive and sometimes associated with massive bleeding. The requirement of a major surgical procedure in cases with airway abnormalities and cardiac dysfunction may result in considerable risk for anesthesia-related complications. Along with standardization of new MPS therapy options, the need for anesthesia in such characteristic high-risk adult cases will increase in the near future, for which anesthesiologists must be prepared.

Conclusion

Adult MPS patients may have substantial risks related to anesthesia, especially in regard to airway and circulatory management. Preparation of airway management devices in advance, including a fiberoptic bronchoscope, as well as close circulatory volume monitoring and management is an important key for safe anesthesia in such patients undergoing major spine surgery.

Acknowledgements

This work was supported in part by grants from JSPS KAKENHI (No. 26462371, 23592309).

Statement of Ethics

The authors have no ethical conflicts to disclose.

Disclosure Statement

The authors have no competing interests to declare in regard to this study.

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