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A simplified approach for anaesthetic management of diagnostic procedures in children with anterior mediastinal mass

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ABSTRACT

Introduction: Children with anterior mediastinal mass (AMM) need general anaesthesia (GA) or deep sedation for diagnostic procedures more often than adult patients. Anaesthetic management to prevent such complications includes maintenance of spontaneous ventilation (SV) and prebiopsy corticosteroid/radiotherapy.

Methods: We reviewed the medical records of children with AMM who were brought to the operating theatre for diagnostic procedures (prior to chemotherapy) between 2001 and 2013. Our aim was to describe the clinical features, radiological findings and anaesthetic management as well as determine any association with complications.

Results: 25 patients (age range: 10 months–14 years) were identified during the study period. Corticosteroid therapy was started before biopsy for one patient. All 25 patients had GA/sedation. A senior paediatric anaesthesiologist was involved in all procedures. Among 13 high-risk patients, SV was maintained in 11 (84.6%) patients, ketamine was used as the main anaesthetic in 8 (61.5%) patients, 6 (46.2%) patients were in a sitting position and no airway adjunct was used for 7 (53.8%) patients. There were 3 (12.0%) minor complications.

Conclusion: Based on our results, we propose a simplified workflow, wherein airway compression of any degree is considered high risk. For patients with high-risk features, multidisciplinary input should be sought to decide whether the child would be either fit for a procedure under GA/sedation or considered unfit for any procedure. Recommendations include the use of less invasive methods, involving experienced anaesthesiologists to plan the anaesthetic technique and maintaining spontaneous ventilation.

Keywords: diagnostic procedure, ketamine, simplified approach, spontaneous ventilation, untreated anterior mediastinal mass

INTRODUCTION

Children with anterior mediastinal mass (AMM) need general anaesthesia (GA) or deep sedation for diagnostic procedures more often than adult patients. Anaesthesia-related morbidity and mortality have been associated with the presence of orthopnoea, upper body oedema, stridor, major vessel compression, tracheal/bronchial compression, dynamic compression on spirometry and large pericardial effusion.[1-8] Anaesthetic management to prevent such complications includes the maintenance of spontaneous ventilation (SV) and prebiopsy corticosteroid/radiotherapy.[1,4-11]

We reviewed the medical records of children with AMM who were brought to the operating theatre for diagnostic procedures. Our aim was to describe the clinical features, radiological findings and anaesthetic management methods used in these patients as well as determine whether there was any association with complications.

METHODS

Following approval from the institutional review board, retrospective case note evaluation was done of children diagnosed with AMM between 2001 and 2013 at KK Women's and Children's Hospital, Singapore. We included all children who had undergone diagnostic procedures in the operating theatre while excluding children who had already received chemotherapy other than corticosteroid therapy. Information on the demographic characteristics, diagnosis, clinical presentation, computed tomography/magnetic resonance imaging findings, anaesthetic management and perioperative critical incidents were recorded.

Anaesthetic management was analysed based on the type of ventilation maintained, anaesthetic agents used and the risk status of patient. Patients who presented with upper body oedema, stridor, major vessel compression, tracheal/bronchial compression and large pericardial effusion were considered high risk.[2,6-8] As the term 'orthopnoea' was not consistently used in

the patients' case notes, all patients who presented with dyspnoea with postural exacerbation were considered to be at high risk.

RESULTS

25 patients, aged between 10 months and 14 years, with AMM were identified within the study period. There were 14 (56.0%) boys and 11 (44.0%) girls. The various diagnoses included lymphoma in 21 (84.0%) patients, and neuroblastoma, ganglioblastoma, malignant rhabdoid tumour and mucoepidermoid carcinoma in 1 (4.0%) patient each. 6 (24.0%) patients had airway compression at the tracheal or bronchial level (Table I). Among 11 (44.0%) patients who had compression of the major vessels, three patients did not have any cardiorespiratory symptoms.

Table I. Relationship between radiological features of cardiorespiratory involvement and preoperative symptoms suggestive of mass effect among patients with anterior mediastinal mass (n = 25).

Respiratory and cardiovascular involvement on CT/MR imaging	**No. (%)**	
	Patients with cardiorespiratory symptoms*	**Patients with no cardiorespiratory symptoms†**
Tracheal/bronchial compression	6 (24.0)	-
Superior vena cava/ brachiocephalic vein compression	9 (36.0)	2 (8.0)
Pulmonary artery obstruction	2 (8.0)	1 (4.0)
Large pericardial effusion	1 (4.0)	-
Involvement of only mediastinal lymph nodes	-	3 (12.0)

**Dyspnoea, upper body oedema, stridor, cough and chest pain. †Fever, neck swelling, axillary swelling, weight loss, abdominal pain and groin swelling. CT: computed tomography; MR: magnetic resonance*

2 (8.0%) patients received corticosteroids to reduce mass size before surgery. One of them had been diagnosed at another hospital and had been administered prednisolone prior to transfer to our centre.

All procedures were performed under GA or sedation. A senior paediatric anaesthesiologist (with over five years' experience) was in charge in the operating theatre for

all procedures. For 6 (24.0%) patients, the biopsy sample was taken from extramediastinal sites; for 3 (12.0%) patients, ultrasonography-guided needle biopsy of the AMM was performed; and for 16 (64.0%) patients, open/thoracoscopic biopsy of the AMM was performed.

In our study, 13 (52.0%) patients were considered as high risk (Table II). SV was more frequently maintained in these patients (n = 11, 84.6%) than among low-risk patients (n = 7, 58.3%). Of the two high-risk patients who were managed with positive pressure ventilation, one patient had presented to the emergency department with respiratory distress and was already intubated and paralysed. To maintain SV, during the initial years of the review (2000–2006), sevoflurane (12/14 patients, 85.7%) was the preferred anaesthetic agent, whereas during the later years (2007–2013), ketamine (7/11 patients, 63.6%) was the preferred agent.

There were 3 (12.0%) complications – respiratory events in two patients and a cardiovascular event in one patient – all of which occurred in high-risk patients (Table III). All three patients had cardiorespiratory symptoms and radiological evidence of major vessel compression. One of the complications happened at induction, while the other two events occurred at the end of the operation. Statistical analysis of the complications was not possible on account of the small number of events in our study population.

DISCUSSION

The absence of cardiorespiratory symptoms in our patients did not necessarily imply low risk (Table I). Among the five patients with no cardiorespiratory symptoms, three patients had major vessel compression on radiography, which is a feature associated with anaesthetic complications.[6,8]

Corticosteroid or radiotherapy before biopsy can considerably reduce the size of the mass and thereby decrease the risk of GA or sedation, but it may also preclude the biopsy of

AMM and thereby hinder accurate diagnosis.[2,10,12] Corticosteroid therapy was started before biopsy in one patient at our hospital and the procedure was done after the risk was deemed to be lowered. This 11-year-old patient was only able to assume the right lateral decubitus position, and computed tomography showed that AMM was causing compression of the trachea and narrowing of the left and right main bronchi, superior vena cava and main pulmonary artery. After multidisciplinary input from oncologists, surgeons, radiologists and anaesthesiologists, the patient was considered unfit to undergo biopsy of AMM due to a combination of cardiorespiratory symptoms and radiological findings.

A tracheal cross-sectional area or peak expiratory flow rate less than 50% of predicted value based on age and gender has been suggested to indicate that the patient is unfit for GA.[1,10,13] The calculation for tracheal cross-sectional area compression was not done for any patient in our study. Neither was there any test for dynamic compression, such as peak expiratory flow rate. To get a child to test for peak expiratory flow rate and obtain reliable reading is difficult and thus not used to assess the risk associated with GA at our hospital.[14,15]

Biopsy in high-risk patients under local anaesthesia, with or without conscious sedation, has been reported, but it is not clear whether all such patients received an anaesthetic intervention.[5,15] In our series, all patients did receive anaesthetic intervention – a senior paediatric anaesthesiologist being in charge of anaesthetics in the operating theatre for all our patients might have been a reason for this.

For high-risk patients with AMM, maintaining SV is important, as the negative intrathoracic pressure during inhalation pulls the mass away from the airway and major vessels. Positive pressure ventilation may cause turbulence and ineffective gas exchange in the airways compressed and narrowed by the AMM.[4,8] Both inhalation anaesthetic agents (e.g. sevoflurane and isoflurane) and the intravenous anaesthetic agent ketamine can be used to anaesthetise patients while maintaining SV. Ketamine maintains intercostal and chest wall tone

better than inhalational agents; as a result, it does not cause atelectasis in spontaneously breathing patients.[8,11,16] The increase in the use of ketamine in the later years of our study was probably due to greater awareness of its advantages. Assuming the sitting or lateral position during the diagnostic procedure may be beneficial as in the supine position, gravity pushes the mass onto the airways and major vessels, and also reduces the intrathoracic space (cephalad movement of the diaphragm and increased central thoracic volume).[4,13] The choice of anaesthetic and positioning seemed to have been based on the risk status of patients in our study. For high-risk patients, ketamine was more frequently used to maintain anaesthesia/sedation (8/13 patients, 61.5%), patients were more likely to be positioned in the sitting position (6/13 patients, 46.2%) and fewer patients needed airway adjunct (7/13 patients, 53.8%). However, such a correlation could not be shown because of our small sample size.

The complications in the present series of patients were minor and comparable to those reported in other series.[1,10,14,15] Complications in our study highlight the delicate balance needed for anaesthetic management. In the case of the first patient who developed complication, when the patient was placed in a supine position after biopsy was done in the right lateral position, there was complete airway compression. It is possible that the use of the inhalational agent (sevoflurane), positive pressure ventilation and oedema/bleeding into the mass due to the biopsy may all have contributed to this.

Patients for whom AMM compresses the major vessels may be relatively asymptomatic while awake but on the loss of muscle tone after administration of an anaesthetic agent may develop severe life-threatening hypotension due to complete compression and resultant interruption of cardiac output.[8] The second patient who developed complication had compression of the pulmonary artery by AMM. This patient was in a sitting position throughout the procedure and anaesthetic management was done with ketamine, which preserves muscle tone. Though there was significant hypotension at the end of the procedure, it was corrected

with fluid boluses and there was no further deterioration in the patient. Respiratory infection contributes to the risk of GA in AMM.[3] Pulmonary consolidation/collapse can cause ventilation-perfusion mismatch and slower induction with less soluble inhalational agents, such as sevoflurane. The slower inhalational induction may have resulted in a lighter plane of anaesthesia during airway intervention and subsequent laryngospasm, which was the complication seen in the third patient in our study.

Based on our results, we propose a simplified (albeit conservative) workflow that can be applied to children with AMM undergoing diagnostic procedures to enable safe anaesthetic intervention (Fig. 1). Airway compression of any degree is considered high risk in our workflow, unlike other algorithms, such as that proposed by Neuman et al, which includes tracheal cross-sectional area and peak expiratory flow rate to stratify risk.[4,15,17] In those with a high-risk feature, multidisciplinary input from the various clinicians involved, including oncologists, anaesthesiologists and proceduralists (paediatric surgeon/radiologist), should be sought prior to decision-making – based on a combination of clinical and radiological findings – on whether the child should be considered fit for a procedure under GA/sedation or unfit for any procedure in the untreated state. This feature differs from other existing algorithms, such as that proposed by Lerman et al,[4] where procedures are categorised as fit to be done under local anaesthesia with or without sedation or fit to be done under GA.[5,15,17] For patients considered fit for a diagnostic procedure, recommendations included the use of less invasive methods to obtain the specimen and involving an experienced anaesthesiologist to plan the anaesthetic technique and maintaining spontaneous ventilation.

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Table II. Anaesthetic management of children considered high risk and those without any high-risk features (n = 25).

Risk status	**Anaesthetic management (no. [%])**										
	Ventilation		**Maintenance**			**Position**			**Airway**		
	SV	**PPV**	**Ketamine**	**Sevoflurane/ isoflurane**	**Ketamine + sevoflurane**	**Supine**	**Sitting**	**Lateral**	**Without airway adjunct**	**Supraglottic airway**	**Endotracheal tube**
High risk (one high-risk feature)* (n = 13)	11 (84.6)	2 (15.4)	8 (61.5)	5 (38.5)	-	7 (53.8)	6 (46.2)	-	7 (53.8)	3 (23.1)	3 (23.1)
Low risk (no high-risk feature) (n = 12)	7 (58.3)	5 (41.7)	1 (8.3)	10 (83.3)	1 (8.3)	7 (58.3)	3 (25.0)	2 (16.7)	2 (16.7)	5 (41.7)	5 (41.7)

**Clinical features included dyspnoea with postural exacerbation, upper body oedema or stridor; radiological features included tracheal compression/bronchial compression, superior vena cava compression, pulmonary artery compression or large pericardial effusion. PPV: positive pressure ventilation; SV: spontaneous ventilation*

Table III. Details of patients with anaesthetic complications.

Case no.	Age (yr)/ gender	Primary diagnosis	Procedure	Clinical presentation	CT/MR imaging finding	Main anaesthetic/ ventilation	Position	Complication	Management
1	9/M	Non-Hodgkin's lymphoma	Transthoracic biopsy of AMM and bone marrow aspiration	Cough and facial swelling	Compression of the SVC	Sevoflurane/PPV	Right lateral	• Unable to ventilate after patient was shifted to supine position at the end of procedure • No tidal volume with the same pressure-controlled ventilation settings	Endotracheal tube pushed into the right main bronchus, and slowly withdrawn under fibreoptic scope guidance. Tracheal compression above carina noticed, and tube tip positioned below compression
2	14/M	Malignant rhabdoid tumour	Excision biopsy of cervical lymph nodes	Fever and chest pain	Compression of main pulmonary artery	Ketamine/SV	Supine	Hypotension while shifting to the intensive care unit	Multiple fluid boluses
3	3/M	Non-Hodgkin's lymphoma	Excision biopsy of AMM	Cough, fever, dyspnoea and facial swelling	Trachea deviated to the right, SVC and innominate vein obstruction	Sevoflurane/SV	Sitting	Laryngospasm and desaturation at induction	Anaesthesia deepened with sevoflurane and propofol

AMM: anterior mediastinal mass; CT: computed tomography; F: female; M: male; MR: magnetic resonance; PPV: positive pressure ventilation; SV: spontaneous ventilation; SVC: superior vena cava

FIGURE

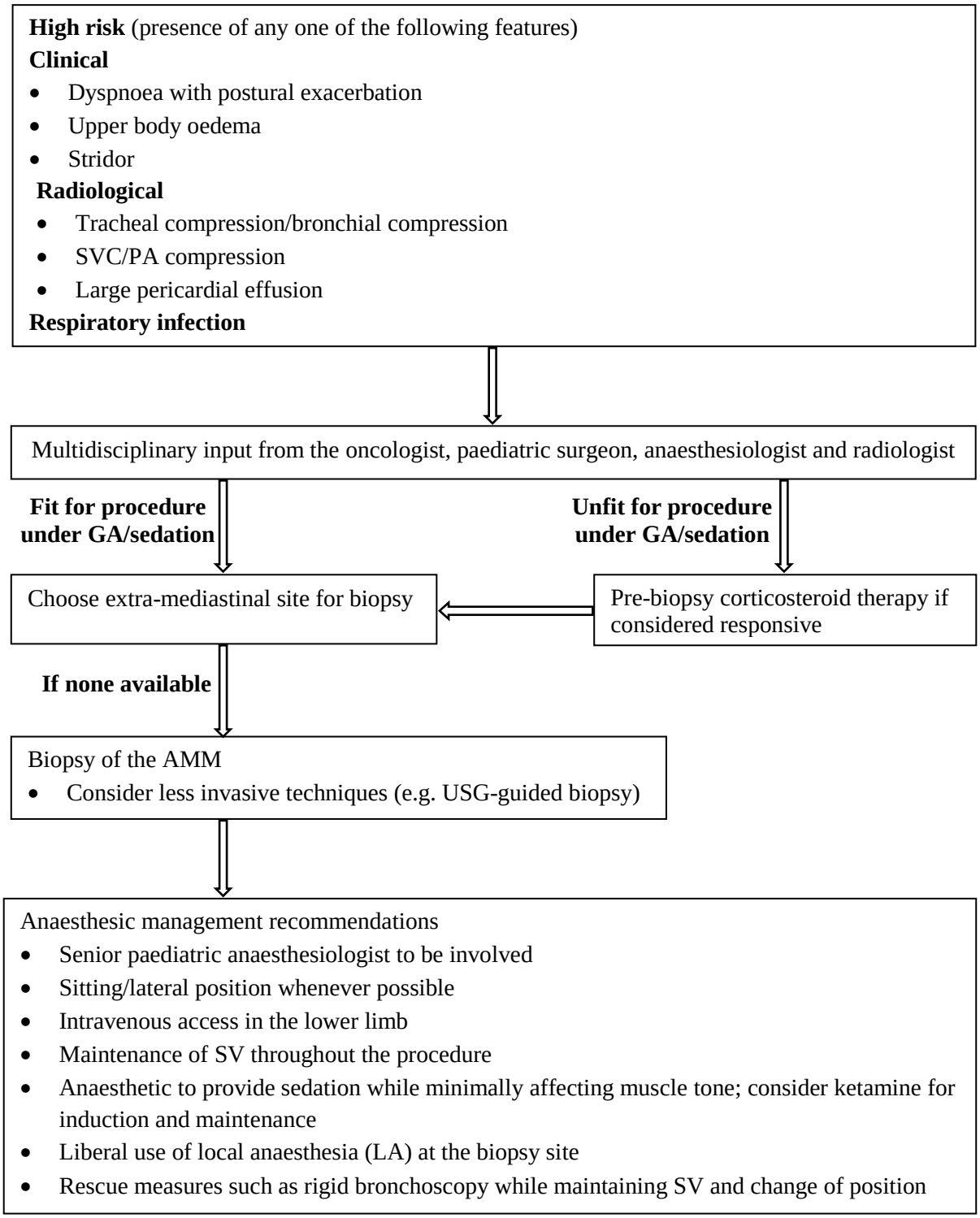

Fig. 1 Flowchart showing risk stratification and anaesthetic management of children with AMM. AMM: anterior mediastinal mass; GA: general anaesthesia; LA: local anaesthesia; PA: pulmonary artery; PPV: positive pressure ventilation; SV: spontaneous ventilation; SVC: superior vena cava; USG: ultrasonography