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

Challa Satish Kumar Reddy1, MMed, Daniel Li Khai Phang2, MMed, Agnes Suah Bwee Ng3, MMed, Ah Moy Tan4, MMed, FRCPE

INTRODUCTION

Children with an 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 corticosteroids/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 the 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 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 SV.

Keywords: diagnostic procedure, ketamine, simplified approach, spontaneous ventilation, untreated anterior mediastinal mass
patients who had compression of the major vessels, three patients did not have any cardiorespiratory symptoms.

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 six patients with no cardiorespiratory symptoms, three patients had major vessel compression on radiography, which is a feature associated with anaesthetic complications.¹,⁵

Corticosteroids 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.¹,⁵,⁶,¹² 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.

It has been suggested that a tracheal cross-sectional area or peak expiratory flow rate less than 50% of the predicted value based on age and gender indicates that a patient is unfit for GA.¹,¹⁰,¹¹ The calculation for tracheal cross-sectional area compression was not done for any patient in our study, and neither was any test for dynamic compression, such as peak expiratory flow rate. Testing for peak expiratory flow rate in children and

---

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

| Respiratory/cardiovascular involvement                     | No. (%)          |
|------------------------------------------------------------|------------------|
| Tracheal/bronchial compression                              | 6 (24.0)        |
| Superior vena cava/brachiocephalic vein compression         | 9 (36.0)        |
| Pulmonary artery obstruction                                | 2 (8.0)         |
| Large pericardial effusion                                  | 1 (4.0)         |
| Involvement of only mediastinal lymph nodes                 | –               |

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

| Variable                  | High risk* (n = 13) | Low risk (n = 12) |
|---------------------------|---------------------|-------------------|
| Ventilation               |                     |                   |
| SV                        | 11 (84.6)           | 7 (58.3)          |
| PPV                       | 2 (15.4)            | 5 (41.7)          |
| Maintenance               |                     |                   |
| Ketamine                  | 8 (61.5)            | 1 (8.3)           |
| Sevoflurane/isoflurane    | 5 (38.5)            | 10 (83.3)         |
| Ketamine + sevoflurane    | –                   | 1 (8.3)           |
| Position                  |                     |                   |
| Supine                    | 7 (53.8)            | 7 (58.3)          |
| Sitting                   | 6 (46.2)            | 3 (25.0)          |
| Lateral                   | –                   | 2 (16.7)          |
| Airway                    |                     |                   |
| Without airway adjunct    | 7 (53.8)            | 2 (16.7)          |
| Supraglottic airway       | 3 (23.1)            | 5 (41.7)          |
| Endotracheal tube         | 3 (23.1)            | 5 (41.7)          |

*High risk was defined as having one high-risk feature and low risk as having no high-risk features. *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.
obtaining reliable readings is difficult and is 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.\(^{3,11,16}\)

In our series, all patients did receive anaesthetic intervention – possibly because a senior paediatric anaesthesiologist was in charge of anaesthetics in the operating theatre for all our patients.

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.\(^{14,16}\) 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).\(^{14,13}\) 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 an 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.\(^{13,15,14,13}\) 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 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.\(^{16}\) 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. Although there was significant hypotension at the end of the procedure, it was corrected with fluid boluses and there was no further

| 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 | Endotracheal tube pushed into the right main bronchus and slowly withdrawn under fiberoptic 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; M: male; MR: magnetic resonance; PPV: positive pressure ventilation; SV: spontaneous ventilation; SVC: superior vena cava
High risk (presence of any one of the following features)

- Dyspnoea with postural exacerbation
- Upper body oedema
- Stridor
- Radiological
- Tracheal compression/bronchial compression
- SVC/PA compression
- Large pericardial effusion
- Respiratory infection

Multidisciplinary input from the oncologist, paediatric surgeon, anaesthesiologist and radiologist

Fit for procedure under GA/sedation

- Pre-biopsy corticosteroid therapy if considered responsive

Unfit for procedure under GA/sedation

- Choose extra-mediaistinal site for biopsy

Biopsy of the AMM

- Consider less invasive techniques (e.g. US-guided biopsy)

Anaesthetic management recommendations

- Senior paediatric anaesthesiologist to be involved
- Sitting/lateral position whenever possible
- Intravenous access in the lower limb
- Maintenance of SV throughout the procedure
- Anaesthetic to provide sedation while minimally affecting muscle tone; consider ketamine for induction and maintenance
- Liberal use of local anaesthesia at the biopsy site
- Rescue measures such as rigid bronchoscopy while maintaining SV and change of position

Fig. 1 Flowchart shows 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; US: ultrasonography

deterioration in the patient. Respiratory infection contributes to the risks associated with GA in AMM.\textsuperscript{39} 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 as that proposed by Neuman et al, which includes tracheal cross-sectional area and peak expiratory flow rate to stratify risk.\textsuperscript{[16,17]} 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,\textsuperscript{46} in which procedures are categorised as fit to be done under local anaesthesia, with or without sedation, or fit to be done under GA.\textsuperscript{[5,13,17]} For patients considered fit for a diagnostic procedure, recommendations included the use of less invasive methods to obtain the specimen, involving an experienced anaesthesiologist to plan the anaesthetic technique and maintaining SV.

REFERENCES

1. Stricker PA, Gurnaney HG, Litman RS. Anaesthetic management of children with an anterior mediastinal mass. J Clin Anesth 2010; 22:159-63.
2. Ferrari LR, Bedford RF. General anaesthesia prior to treatment of anterior mediastinal masses in pediatric cancer patients. Anesthesiology 1990; 72:991-5.
3. Ng A, Bennett J, Bromley P, Davies P, Morland B. Anaesthetic outcome and predictive risk factors in children with mediastinal tumours. Pediatr Blood Cancer 2007; 48:160-4.
4. Lerman J. Anterior mediastinal masses in children. J Clin Anesth 2007; 26:133-40.
5. Perger I, Lee EY, Shanberger RC, Management of children and adolescents with a critical airway due to compression by an anterior mediastinal mass. J Pediatr Surg 2008; 43:1990-7.
6. Angelescu DL, Burgoyne LL, Liu T, et al. Clinical and diagnostic imaging findings predict anesthetic complications in children presenting with malignant mediastinal masses. Pediatr Anesth 2007; 17:1090-8.
7. Dilworth KE, McHugh K, Stacey S, Howard RF. Mediastinal mass obscured by a large pericardial effusion in a child: a potential cause of serious anaesthetic morbidity. Paediatr Anaesth 2001; 11:479-82.
8. Pullerits J, Holzman R. Anaesthesia for patients with mediastinal masses. Can J Anesth 1989; 36:681-8.
9. Frawley G, Low J, Brown TC. Anaesthesia for an anterior mediastinal mass with ketamine and midazolam infusion. Anaesth Intensive Care 1995; 23:610-2.
10. Hack HA, Wright NB, Wynn RF. The anaesthetic management of children with anterior mediastinal masses. Anaesth Intensive Care 1995; 23:610-2.
11. Piastra M, Ruggiero A, Caresta E, et al. Life-threatening presentation of mediastinal neoplasms: report on 7 consecutive pediatric patients. Am J Emerg Med 2005; 23:76-82.
12. Borenstein SH, Gerstle T, Malikin D, Thurner P, Filler RM. The effects of prebiopsy corticosteroid treatment on the diagnosis of mediastinal lymphoma. J Pediatr Surg 2000; 35:973-6.
13. Shanberger RC. Preanesthetic evaluation of children with anterior mediastinal masses. Semin Pediatr Surg 1999; 8:61-8.
14. Acker SN, Linton J, Tan GM, et al. A multidisciplinary approach to the management of anterior mediastinal masses in children. J Pediatr Surg 2015; 50:875-8.
15. Carey CI, Laituri CA, Valuek PA, St Peter SD, Snyder CI. Management of anterior mediastinal masses in children. Eur J Pediatr Surg 2011; 21:310-2.
16. Drummond GB. Comparison of sedation with midazolam and ketamine: effects on airway muscle activity. Br J Anaesth 1996; 76:663-7.
17. Neuman GG, Weingarten AE, Abramowitz RM, et al. The anaesthetic management of the patient with an anterior mediastinal mass. Anesthesiology 1984; 60:144-7.