The Journal of Laryngology & Otology

cambridge.org/jlo

Endoscopic cricoid split in a tertiary referral paediatric centre

S Carr, A Dritsoula and R Thevasagayam

Department of Otolaryngology, Sheffield Children's Hospital, UK

Abstract

Background. Anterior cricoid split is performed for grade 2 and 3 subglottic stenosis, which can be a cause of extubation failure. It can be performed endoscopically or as an open procedure. This paper describes a case series of endoscopic cricoid split procedures performed using a bespoke sickle knife.

Method. Nine patients (six pre-term infants) underwent endoscopic cricoid split in a tertiary referral paediatric unit between August 2012 and March 2015.

Results. Six patients (67 per cent; four pre-term and two term infants) were on oxygen pre-operatively. Mean age at operation was 30 weeks (range, 11–104 weeks). Mean number of days' intubation was 5.6 days (range, 4–9 days). All five patients intubated pre-operatively were extubated. Seven patients required repeat dilatations. One patient required tracheostomy.

Conclusion. The extubation rates for endoscopic cricoid split are comparable to the open procedure. It is a safe and efficient method for managing subglottic stenosis, whether acquired or congenital. The main advantage is the shorter operative time, in addition to the avoidance of an external scar and drain.

Main Article

Mr S Carr takes responsibility for the integrity of the content of the paper

Presented as a poster at the British Academic Conference in Otolaryngology, 8–10 July 2015, Liverpool, and orally at the British Association of Paediatric Otolaryngology, 18 September 2015, Belfast, Northern Ireland, UK.

Cite this article: Carr S, Dritsoula A, Thevasagayam R. Endoscopic cricoid split in a tertiary referral paediatric centre. *J Laryngol Otol* 2018;**132**:753–756. https://doi.org/10.1017/S0022215118001226

Accepted: 4 March 2018
First published online: 16 July 2018

Key words:
Acquired Subglottic Stenosis; Congenital Subglottic Stenosis; Endoscopy; Surgery

Author for correspondence:
Mr S Carr,
Department of Otolaryngology,
Sheffield Children's Hospital,
Western Bank,
Sheffield S10 2TH, UK
E-mail: Simoncarr15@gmail.com

Introduction

Anterior cricoid split is a procedure performed for grades 2 and 3 subglottic stenosis, which can be carried out endoscopically or as an open procedure. The open procedure was originally described by Cotton and Seid as an alternative to tracheostomy for patients in whom extubation failed because of subglottic stenosis.[1]

In our unit, anterior cricoid split is performed endoscopically as we believe it to be superior to the open method. To facilitate this, a bespoke sickle knife was developed in conjunction with the company Single Use Surgical (Cardiff, Wales, UK).

This paper describes a case series of patients who underwent endoscopic anterior cricoid split and balloon dilatation for extubation failure and mature stenosis. The study aimed to assess the success rate of endoscopic cricoid split in our unit and to review the indications for the procedure.

Materials and methods

Ethical considerations

No ethics approval was sought for this study.

Study design

A retrospective case note review was performed of all paediatric patients who underwent endoscopic cricoid split in a tertiary referral paediatric ENT unit between August 2012 and March 2015. The degree of subglottic stenosis was graded according to the Cotton–Myer grading system.

Surgical procedure

Endoscopic anterior cricoid split is performed with the patient spontaneously ventilating, or apnoeic if this is not possible. A microlaryngoscopy and bronchoscopy is performed to: confirm the diagnosis, grade the stenosis and assess the remainder of the airway.

The assistant holds the endoscope whilst the surgeon uses a bespoke sickle knife (Single Use Surgical) (Figure 1) to perform the anterior cricoid split (Figure 2). The operating surgeon places their other hand externally on the anterior neck to stabilise the cricoid and to judge the depth of the split. The sickle knife divides the first two tracheal rings of the cricoid and lower thyroid cartilage. The endoscope allows the surgeon to identify the subglottis, so that the upper limit of the incision is just below the anterior commissure of the vocal folds.

The subglottis is subsequently dilated with an age-appropriate oesophageal balloon (Boston Scientific, Marlborough, Massachusetts, USA) and dilated for two sets of

Fig. 1. Purpose-built sickle knife.

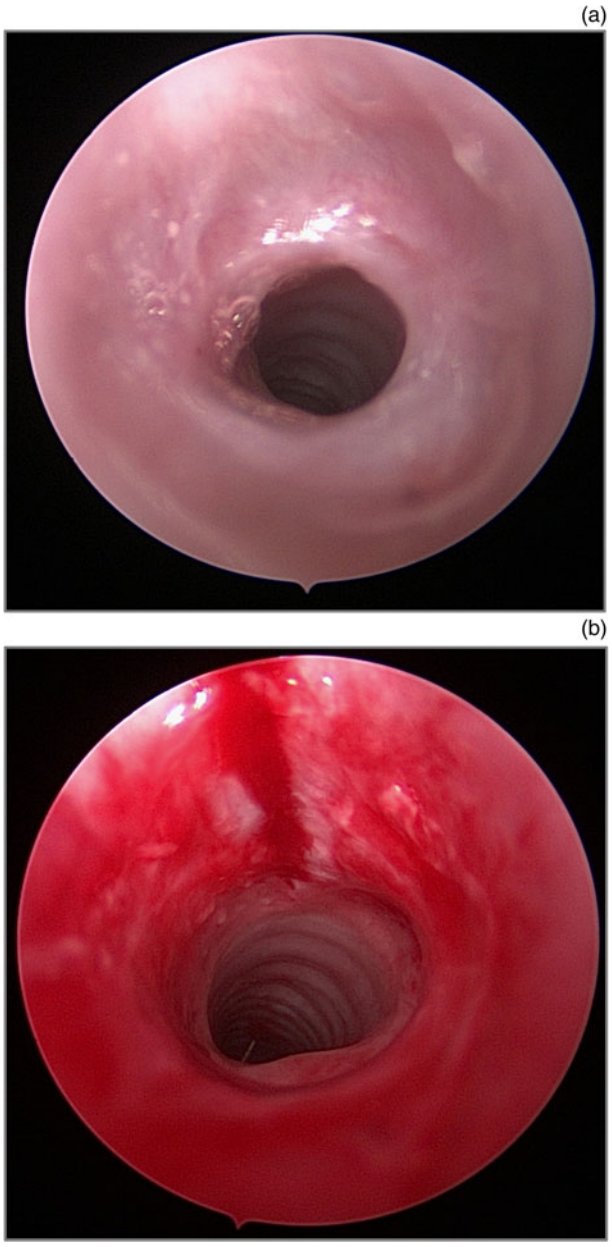

Fig. 2. (a) Endoscopic view of grade 3 subglottic stenosis, and (b) view following endoscopic cricoid split and balloon dilatation.

90 seconds each. The balloon diameter was chosen equal to the expected cricoid diameter plus 1 mm, using the Great Ormond Street Hospital chart for sizing paediatric airways.[2]

The patient is intubated with an age-appropriate endotracheal tube and ventilated on the intensive care unit for approximately 5 days, after which they are extubated (steroids are administered prior to extubation).

Results

Nine patients underwent an endoscopic cricoid split procedure between August 2012 and March 2015, five for failure to extubate and four for treatment of an established subglottic

Table 1. Demographics and clinical outcome of patients undergoing endoscopic cricoid split

Patient age (weeks)	Body weight (kg)	Subglottic stenosis grade	Pulmonary function, O_2 requirement & co-morbidities	Intubated pre-op?	ETT size post-op (mm)	Duration intubation post-op (days)	Repeat balloon dilatations (*n*)	Follow-up duration (months)	Extubated post-op?
15; CGA 1	3.7	3 (subglottic cysts)	CLD; pre-op O_2 required	No	3.5	5	1	5	Yes
11; CGA 1	2.4	3	Pulmonary lymphangiectasia; no O_2 required	No	3.5	4	2	15	Yes
14; CGA 1	2.0	2	CLD; pre-op O_2 required	No	3.5	5	1	14	Yes
20; CGA 5	3.6	2	No O_2 required	Yes	3.5	4	2	22	Yes
20; CGA 4	3.7	3	CLD; pre-op O_2 required	No	4.0	7	1	Died	No
30; CGA 16	1.8	1 (subglottic cysts)	CLD; CPAP required	Yes	4.0	8	0	5	Yes
44 term	7.7	2	CHARGE; pre-op O_2 required	Yes	4.0	9	2	5	Yes
104 term	10.3	2	No O_2 required	Yes	5.0	5	0	4	Yes
11 term	3.6	3	Pre-op O_2 required	Yes	3.5	4	2	8	Yes

O_2 = oxygen; pre-op = pre-operatively; ETT = endotracheal tube; post-op = post-operatively; CGA = corrected gestational age; CLD = chronic lung disease; CPAP = continuous positive airway pressure; CHARGE = coloboma, heart defects, atresia choanae, growth retardation, genital abnormalities and ear abnormalities syndrome

https://doi.org/10.1017/S0022215118001226 Published online by Cambridge University Press

Table 2. Summary of published studies of open anterior cricoid split

Study (year)	Patients (*n*)	Results	Complications
Cotton & Seid (1980)[1]	12	9 (75%) extubated; 3 (25%) required tracheostomy	1 neck wound infection; 2 deaths unrelated to surgery
Pashley (1984)[3]	22	18 (82%) extubated; 4 (18%) required LTR	1 subcutaneous haematoma; 1 pneumothorax
Seid & Canty (1985)[4]	22	18 (82%) extubated; 4 (18%) required tracheostomy	1 surgical emphysema; 1 abscess at wound site. 9 complications unrelated to surgery (8 lobar or segmental collapse due to mucus obstruction & 1 scalp necrosis post-ACS)
Holinger *et al.* (1987)[5]	26	20 (77%) extubated; 6 (23%) required tracheostomy	6 deaths unrelated to surgery; 1 wound breakdown. 2 patients had granulomas at ACS site. Several patients had transient episodes of pneumonia or atelectasis during intubation post-ACS unrelated to surgery
Anderson *et al.* (1988)[6]	26	19 (73%) extubated (3 required tracheostomy); 7 (27%) had failed extubation (3 required tracheostomy)	1 death (autopsy not performed), 2 tracheitis, 2 sepsis, 3 self-extubation, 1 malpositioned ETT
Silver *et al.* (1991)[10]	24	16 (67%) extubated; 8 (33%) required tracheostomy	1 death unrelated to surgery; 1 wound infection
Walker & Forte (1993)[11]	24	20 (83%) extubated; 4 (17%) required tracheostomy	1 premature extubation
Matute *et al.* (2000)[12]	7	5 (71%) extubated; 2 (29%) required LTR	None reported
Eze *et al.* (2005)[13]	33	29 (88%) extubated; 4 (12%) had failed extubation (3 required tracheostomy & 1 remained intubated for prolonged period before being extubated)	1 death unrelated to surgery; 1 surgical emphysema. 2 patients had tracheocutaneous fistula

LTR = laryngotracheal reconstruction; ACS = anterior cricoid split; ETT = endotracheal tube

Table 3. Summary of published studies of endoscopic anterior cricoid split

Study (year)	Patients (*n*)	Surgical method	Results	Complications
Mirabile *et al.* (2010)[8]	18 (10 acquired & 8 congenital subglottic stenosis)	Angioplasty balloon (Cordis, NJ, USA, or Boston Scientific, Marlborough, MA). Diameter of approx. 2 mm larger than age-appropriate size of subglottis. Laryngeal dilatation maintained until saturations dropped to <90%	15 (83%) had good clinical outcome. Treatment failed in 3 (17%): 2/3 required tracheostomy & subsequent LTR, & 1/3 was previously tracheotomised	1 death (cause remains unknown)
Horn *et al.* (2012)[9]	3	Angioplasty balloon (Boston Scientific). Diameter of 8 mm. Duration of dilatation: 45 seconds at 12 atm	2 (67%) extubated; 1 (33%) required tracheostomy	None reported
Current study	9	Refer to Methods section	8 (89%) had good clinical outcome (5/5 extubated); 1 (11%) required tracheostomy	1 death unrelated to surgery; 1 vocal fold injury

LTR = laryngotracheal reconstruction

stenosis (Table 1). Three of the infants were born at term and six were born pre-term, with a mean age at operation of 30 weeks (range, 11–104 weeks). The mean duration of ventilation in the pre-term neonates was 51 days (range, 17–133 days). All of the patients had multiple intubations. Four (67%) of the children born pre-term had chronic lung disease.

The mean age of the patients at operation in those born pre-term was 18 weeks (range, 11–30 weeks) or 5 weeks (range, 1–16 weeks) corrected gestational age, whilst the mean age for those born at term was 53 weeks (range, 11–104 weeks). The mean body weight at operation was 2.9 kg (range, 1.8–3.7 kg) in the pre-term neonates and 7.2 kg (range, 3.6–10.3 kg) in the term neonates.

The mean number of days that the patients were intubated post-operation was 5.6 days (range, 4–9 days). All five patients intubated pre-operatively were extubated.

One child had coloboma, heart defects, atresia choanae, growth retardation, genital abnormalities, and ear abnormalities ('CHARGE') syndrome. This led to multi-level airway obstruction associated with bilateral choanal atresia, laryngomalacia and subglottic stenosis.

Seven patients required repeat balloon dilatations post-operation: three patients required one dilatation and four patients required two dilatations. Those who underwent cricoid split for mature subglottic stenosis had not undergone previous airway procedures.

The operative time for the endoscopic cricoid split was approximately 30 minutes; this was comparatively shorter than the time for the open approach of approximately 80 minutes.

Mean length of follow up was 10 months (range, 4–22 months).

https://doi.org/10.1017/S0022215118001226 Published online by Cambridge University Press

Complications

There was one failure of the endoscopic cricoid split. The child was a pre-term infant, who had been intubated for several weeks, but had been extubated for several days prior to undergoing the cricoid split procedure. The patient was extubated after the operation, but had to be re-intubated because of stridor and poor pulmonary reserve associated with chronic lung disease. Following a repeat balloon dilatation and failed extubation, the child underwent tracheostomy. Unfortunately, the child died as a result of his chronic lung disease.

There was one direct complication, which happened when the senior surgeon was operating without assistance. An inadvertent vocal fold injury occurred when the cricoid split procedure was performed without a hand stabilising the cricoid externally on the neck. The vocal fold healed well, with no further treatment required. The procedure is now always performed with two operators, one holding the endoscope and one performing the cricoid split bi-manually. There were no cases of post-operative surgical emphysema.

Discussion

Every patient who was intubated pre-operatively was extubated following their endoscopic cricoid split procedure. Only one patient was re-intubated as a result of poor pulmonary reserve secondary to chronic lung disease, and eventually underwent tracheostomy, but this patient had been extubated prior to the endoscopic cricoid split procedure.

It is evident from our series that there are two main indications for an endoscopic cricoid split procedure: extubation failure in the neonate; and established subglottic stenosis, which may occur in the older child.

The extubation rate of the endoscopic cricoid split procedure compares favourably with the open method rates of 67–88 per cent quoted in the literature.[1,3–6,10–13] Rotenberg and Berkowitz reported decreased extubation rates with an open cricoid split procedure from 71 per cent in the period 1989–2006 to 41 per cent between 1996 and 2005, which they attributed to an increase in the duration of pre-operative intubation in increasingly premature neonates with a multitude of co-morbidities.[7] They stated that tracheostomy may be a more suitable primary treatment for these neonates and that parents should be counselled accordingly.

Summaries of the published studies on open and endoscopic anterior cricoid split procedures are provided in Tables 2 and 3.[1,3–6,8–13]

Seven patients required repeat balloon dilatations post-operatively, ranging from one to two procedures. Our rate of repeat balloon dilatations is lower than the rates quoted by Mirabile *et al.*[8] In their series of 18 patients, they reported that 83 per cent required dilatations, ranging from 1 to 7 procedures.

In 2010, Mirabile *et al.* were the first to describe the combination of endoscopic cricoid split with balloon dilatation as a treatment for mature subglottic stenosis.[8] In their series, six of eight patients with congenital or acquired stenosis avoided tracheostomy. This is in agreement with our study, as we demonstrated successful outcomes in children with mature stenosis, and all of the children avoided tracheostomy. Our results are better than those of Horn *et al.*, who reported that two of three children avoided tracheostomy.[9]

- The extubation rates for endoscopic cricoid split are at least as good as those for the open procedure
- Endoscopic cricoid split is safe and efficient for managing subglottic stenosis, whether for extubation failure or mature stenosis
- Shorter operative time and scar avoidance make the endoscopic method an attractive alternative to open method for extubation failure in a neonate
- The endoscopic method may also reduce the need for tracheostomy in early subglottic stenosis

We have demonstrated that endoscopic cricoid split is a safe and efficient procedure for the treatment of extubation failure and mature subglottic stenosis. The operative time was shorter when using the endoscope compared to the open procedure; in addition, an external scar and drain could be avoided.

Competing interests. None declared

References

1 Cotton RT, Seid AB. Management of the extubation problem in the premature child: anterior cricoid split as an alternative to tracheotomy. *Ann Otol Rhinol Laryngol* 1980;**89**:508–11
2 Tweedie DJ, Skilbeck CJ, Cochrane LA, Cooke J, Wyatt ME. Choosing a paediatric tracheostomy tube: an update on current practice. *J Laryngol Otol* 2008;**122**:161–9
3 Pashley NR. Anterior cricoidotomy for congenital and acquired subglottic stenosis in infants and children. *J Otolaryngol* 1984;**13**:187–90
4 Seid AB, Canty TG. The anterior cricoid split procedure for the management of subglottic stenosis in infants and children. *J Pediatr Surg* 1985;**20**:388–90
5 Holinger LD, Stankiewicz JA, Livingston GL. Anterior cricoid split: the Chicago experience with an alternative to tracheostomy. *Laryngoscope* 1987;**97**:19–24
6 Anderson GJ, Tom LW, Wetmore RF, Handler SD, Potsic WP. The anterior cricoid split: the Children's Hospital of Philadelphia experience. *Int J Pediatr Otorhinolaryngol* 1988;**16**:31–8
7 Rotenberg BW, Berkowitz RG. Changing trends in the success rate of anterior cricoid split. *Ann Otol Rhinol Laryngol* 2006;**115**:833–6
8 Mirabile L, Serio P, Baggi R, Couloigner V. Endoscopic anterior cricoid split and balloon dilation in pediatric subglottic stenosis. *Int J Pediatr Otorhinolaryngol* 2010;**74**:1409–14
9 Horn DL, Maguire RC, Simons JP, Mehta DK. Endoscopic anterior cricoid split with balloon dilation in infants with failed extubation. *Laryngoscope* 2012;**122**:216–19
10 Silver FM, Myer 3rd CM, Cotton RT. Anterior cricoid split. *Update 1991.* Am J Otolaryngol 1991;**12**:343–6
11 Walker P, Forte V. Failed extubation in the neonatal intensive care unit. *Ann Otol Rhinol Laryngol* 1993;**102**:489–95
12 Matute JA, Villafruela MA, Delgado MD, Berchi FJ, Vazquez J. Surgery of subglottic stenosis in neonates and children. *Eur J Pediatr Surg* 2000;**10**:286–90
13 Eze NN, Wyatt ME, Hartley BE. The role of the anterior cricoid split in facilitating extubation in infants. *Int J Pediatr Otorhinolaryngol* 2005;**69**:843–6

https://doi.org/10.1017/S0022215118001226 Published online by Cambridge University Press