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Original Article

Role of estimation of arterial blood gases in the management of stridor

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Abstract

Aim We studied the epidemiology and etiology of stridor in our patients along with the role of arterial blood gas (ABG) analysis in their management. We also reviewed their prognostic indices and the clinical outcomes.

Materials and methods It was a prospective study in a tertiary referral hospital in which 72 patients presenting with stridor, were independently evaluated by 3 different clinicians and clinically classified into mild, moderate and severe. Based on ABG values (pH, PO2, PCO2), we defined 3 groups of patients viz, those in respiratory failure, impending respiratory failure and those with no evidence of failure. Treatment was directed at the cause of stridor. Clinical outcomes were assessed and results classified as resolved, improved, stable and death.

Results Out of 72 patients, kappa coefficient of agreement between the 3 observers were found to be 0.014, indicating poor interobserver reliability for the working clinical classification. However, ABG analysis indicated otherwise, with 6 patients in respiratory failure, 19 progressing to impending failure. Hence we complied by the more objective ABG analysis in planning management. Laryngomalacia in children and hypopharyngeal malignancies in adults were found to be the most common causes of stridor in our study. As compared to other conditions, laryngomalacia in children had a poorer outcome ($p = 0.001$).

Conclusion Early detection of impending respiratory failure was instrumental in achieving better clinical outcomes in our patients presenting with stridor. Thus we inferred that ABG analysis is a valuable tool in the effective management of stridor.

Keywords Stridor · Blood gas analysis · Tracheostomy · Endotracheal intubation · Respiratory failure

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Introduction

Stridor is defined as a harsh, high pitched, musical sound produced by turbulent airflow through a partially obstructed airway in the larynx, trachea or bronchi [1].

It is a distressing symptom to the patient and his relatives and demands immediate attention and thorough evaluation to uncover the underlying cause. This is because most patients present as an acute respiratory emergency which can turn fatal if patency of airway is not restored immediately. A delay in decision may lead to subsequent cardiopulmonary arrest.

Acute airway obstruction of rapid onset is commonly encountered in all age groups and becomes life threatening if airway is not restored immediately. In children especially, the chief underlying factor is the anatomical variation of larynx compared to an adult. The rima glottidis being smaller in infants wherein, an edema of 1mm thickness can reduce the area by 50% from 24 sq mm to 12 sq mm in the newborn [2], resulting in increased morbidity.

Analysis of blood gases in these patients would thus be a valuable objective parameter for deciding the line of management [3] along with clinical assessment. Thus pH, PO2 and PCO2 values were analyzed with reference to each other and inference was drawn. In our series we attempted to study the significance of ABG estimation and a set of factors that predict prognosis in a patient presenting with stridor.

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Materials and methods

This is a prospective study of 72 patients presenting with stridor in the adult as well as in the pediatric age group, conducted in the Department of Otorhinolaryngology and Head and Neck surgery, at our Institution. Permission to conduct the study was taken from local ethical committee. Patients of all age groups presenting with acute stridor referable to the upper airways were included in a non-randomized manner. Patients with chronic obstructive airway disease, asthma and interstitial lung disease were excluded. Other systemic conditions causing acidosis like renal failure, diabetic ketoacidosis, starvation ketosis and patients on diuretic therapy were excluded. Patients with bleeding disorders and those on anticoagulants were also excluded.

Prospective evaluation included collection of demographic, clinical, laboratory, radiographic, treatment and follow up data. A thorough history provided helpful clues to the underlying etiology of stridor [4] (Fig. 1). On initial presentation with stridor, three different trained observers independently evaluated all patients. The character, severity and quality of stridor were assessed. Particular notice was given to any nasal flaring, sub costal and suprasternal retractions, abdominal movements and cyanosis.

Initial assessment also included the anatomical level of the obstruction. The stridor was categorized into three clinical grades–mild, moderate and severe based on the classification given by Davis and Gartner [5] (Table 1). The findings of three trained observers were recorded to assess the interobserver reliability of the classification. The potential etiology of obstruction was categorized into five specific groups: Congenital, inflammatory, neoplastic, traumatic or idiopathic. Associated co morbidities were noticed and recorded.

Table 1 Clinical assessment of severity of stridor

	Mild	Moderate	Severe
Color	Normal	Normal	Pale/dusky/ cyanotic
Chest retractions	Absent/mild	Moderate	Severe using accessory muscles
Air entry	Mild decrease	Moderate decrease	Severe decrease
State of consciousness	Normal	Anxious, restless	Lethargic, depressed

Routine hematological investigations and serum electrolytes were done in all cases. ABG analysis was done in all cases at the time of presentation and after treatment. Samples were collected from radial artery and immediately analyzed using standardized automated gas analyzer. Radiographs, barium swallow, computerized tomography, endoscopy and biopsy were done as required. Informed consent was obtained from patients and/or family members before each procedure.

The etiology of stridor determined the treatment (Fig. 2). Tracheostomy, intubation and medical care were the various treatment modalities instituted. The decision for doing tracheostomy or intubation was based on clinical assessment and ABG values. Based on ABG values (pH, PO2 and PCO2), we defined three groups of patients (Table 2). When there was a discrepancy in blood gas values, pH was taken as the single criteria for assessing respiratory status.

Clinical outcomes were classified as resolved, improved, stable, failure or death [6]. The term resolved meant that there were no symptoms referable to upper airway; Improved meant there were sub clinical symptoms or signs, and hence Tracheostomy tube was removed. The patient was labelled stable when there was neither a change in airway

Fig. 1 Parapharyngeal abscess following dental infection

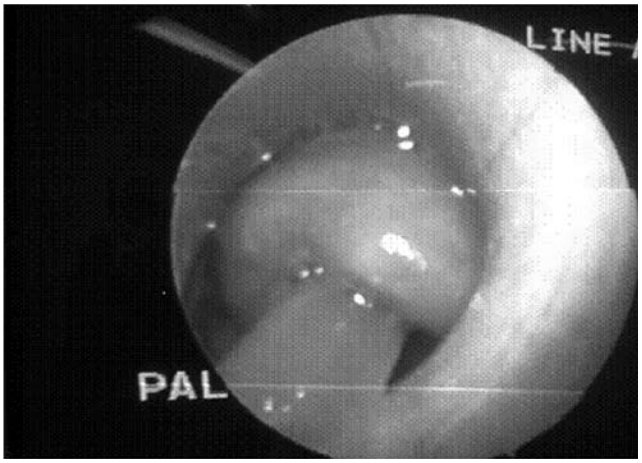

Fig. 2 Acute epiglottitis resulting in stridor

Table 2 Patient categorization based on ABG values [13]

	pH	pO2	pCO2
Respiratory failure	<7.2	<60 mmHg	>49 mmHg
Impending failure	7.2–7.3	60–70 mmHg	45–49 mmHg
No evidence of failure	7.3–7.4	>70 mmHg	<45 mmHg

pH: Negative logarithmic measure of hydrogen ion concentration
pO2: Arterial measure of partial pressure of oxygen
pCO2: Arterial measure of partial pressure of carbon dioxide

symptoms, nor a progression of disease. Also, failure to attain decannulation or improved laryngeal function even after attempts at surgery was defined in our study.

Clinical outcomes were statistically analyzed to assess the significance of various factors that predict the prognosis. The factors that were analyzed included etiology of stridor, pH, PO2 and PCO2 at the time of presentation. Statistical analysis was done using version 14 of SPSS data editor software. The clinical outcomes of different conditions were compared using p-value and the level of significance was set at $p < 0.05$.

Results

The patients included 25 children and 47 adults with a mean age of 32.1 years at the time of presentation. There were 28 females and 44 males in our series. Regarding the clinical classification of stridor, there was agreement between three observers only in 15 cases. In the remaining cases, one observer differed with the other two. Analysis by kappa statistics showed poor interobserver reliability for this classification. (Kappa coefficient of agreement is 0.014).

The pH, PO2 and PCO2 values at the time of presentation and after intervention in adults and pediatric age group are given in Table 3. Considering the three parameters together, in the adults, five patients were in respiratory failure, 11 were in impending respiratory failure and 31 showed no evidence of failure. In the pediatric age group, one patient was in respiratory failure, eight were in impending failure and 16 showed no evidence of failure. Eleven patients had hyponatremia, seven had hypokalemia and three had hypocalcemia in our series. There is no patient presenting with metabolic stridor in our series [7]. The various causes of stridor in our series are listed in Table 4.

Laryngomalacia was the commonest cause of stridor in pediatric age group (36%). In adults, malignancies of hypopharynx accounted for the maximum number of cases (29.78%). Of special interest was a case of skeletal dysplasia characterized by short broad hands, clubfoot, laryngomalacia and meningomyelocele (Maroteaux and Lamy syndrome). Laryngomalacia was associated with meningomyelocele in three children, gastro esophageal reflux in two; clubfoot, skeletal dysplasia, nephrotic syndrome and cerebral palsy in one each.

The details of treatment are shown in Table 5. Tracheostomy was done in 43 adult patients with stridor. Four children underwent tracheostomy, eight underwent intubation and nine were managed conservatively. Ventriculo peritoneal shunting was done in two patients with hydrocephalus. The tracheobronchial foreign body

Table 3 Distribution of pO2 , pCO2 and pH pre and post intervention

	pO2 in adults		pO2 in children	
	Pre intervention	Post intervention	Pre intervention	Post intervention
<60 mmHg	5	5	1	–
60–70 mmHg	14	3	10	–
>70 mmHg	28	39	14	25
	pCO2 in adults		pCO2 in children	
	Pre intervention	Post intervention	Pre intervention	Post intervention
> 49 mmHg	5	5	1	–
45–49 mmHg	12	4	9	1
40–45 mmHg	30	38	15	24
	pH in adults		pH in children	
	Pre intervention	Post intervention	Pre intervention	Post intervention
7.4–7.3	31	41	16	24
7.3–7.2	5	1	8	1
<7.2	11	5	1	0

mmHg: Millimeters of mercury

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Table 4 Causes of stridor in our study

Malignancy oropharynx	5	Post radiation stridor	4
Malignancy hypopharynx	14	Post extubation	1
Malignancy larynx	11	Post thyroidectomy	2
Carcinoma thyroid	3	Subglottic stenosis	2
Epiglottitis	6	Foreign bodies	2
Croup	2	Chemical pnuemonitis	1
Ludwigs angina	3	Parapharyngeal abscess	1
Laryngomalacia	9	Hydrocephalus	2
Laryngocele	1	Acute lymphatic luekemia (ALL)	1
Parkinsonism	1	Mediastinal mass	1

in two patients were removed using rigid bronchoscopy. Laryngocele was suitably excised. The outcome of various conditions are listed in Table 6.

All five adults who had respiratory failure at the time of presentation succumbed to death despite of doing tracheostomy, whereas the lone child who was in respiratory failure eventually survived. Stridor completely resolved following removal of foreign bodies in children. The two cases of hydrocephalus showed remarkable improvement following shunt surgery. Stridor in deep neck space infections resolved following tracheostomy and surgical drainage.

Discussion

The parameters used in the clinical classification of stridor were highly subjective and interobserver reliability of this working classification scheme was poor as shown by Kappa statistics. The finding of 8 children and 11 adults going towards a respiratory failure sharply contrasts with the clinical findings. Of these 19 patients (8 + 11), 9 were classified as having a mild stridor by two observers. This shows that clinical assessment can be occasionally misleading and can lead to a delay in the timing of tracheostomy or intubation. Respiratory failure if allowed to progress can lead to circulatory failure [8]. Thus ABG analysis used in our study provided valuable information about the acid base imbalance and respiratory status of the patient helping early intervention.

We used Campbell's data in defining respiratory failure as a measure of blood gas values. Campbell [8] has stated that respiratory failure is said to be present if the pH falls below 7.2, PO2 is below 60 mmHg and PCO2 above 49 mmHg. Five patients who died were in respiratory failure and their

Table 5 Details of treatment in patients presenting with stridor

	Tracheostomy	Intubation	Medical care	Others
Malignancy oropharynx	5			
Malignancy hypopharynx	14			
Malignancy larynx	11			
Carcinoma thyroid	3			
Epiglottitis		6		
Croup		1	1	
Laryngomalacia		1	8	
Laryngocele				1
Post radiation stridor	4			
Post extubation		1		
Post thyroidectomy		2		
Subglottic stenosis	2			
Foreign bodies				2
Chemical pnuemonitis	1			
Parapharyngeal abscess	1			
Ludwigs angina	3			
Hydrocephalus				2
ALL	1			
Parkinsonism	1			
Mediastinal mass	1			

Table 6 Clinical outcome of various conditions presenting with stridor

	Resolved	Improved	Stable	Failure	Death
Malignancy oropharynx		2	3		
Malignancy hypopharynx		2	11		1
Malignancy larynx			10		1
Carcinoma thyroid			3		
Epiglottitis	6				
Croup	2				
Laryngomalacia	6	2	1		
Laryngocele		1			
Post radiation stridor			3		1
Post extubation		1			
Post thyroidectomy		1	1		
Subglottic stenosis			2		
Foreign bodies	2				
Chemical pnuemonitis					1
Parapharyngeal abscess	1				
Ludwigs angina	3				
Hydrocephalus	1	1			
ALL		1			
Parkinsonism			1		
Mediastinal mass					1

ABG values reiterated Campbell's observation and hence it seemed the most appropriate classification for our study. Electrolyte abnormalities in our series were mainly limited to patients with malignant conditions. Such abnormalities were assumed to be due to long term malnourishment.

Majority of the laryngomalacia patients resolved or improved over a period of time following conservative management. This coincides with the findings of other authors [9, 10]. Belmont and Grundfast [10] observed that laryngomalacia probably represents a localized hypotonia rather than an anatomic lesion. The association of laryngomalacia with different states correlates with their finding. All epiglottitis patients were intubated and their stridor resolved completely. All Ludwig's angina patients required tracheostomy. Current literature favored tracheostomy for majority of patients presenting with Ludwig's angina [11]. Deep neck space infections had a good prognosis following tracheostomy and drainage.

Adeloye et al. (1970) [12] and Rath et al. (2006) [13] reported cases where there was complete recovery from stridor when VP shunt surgery was performed for hydrocephalus. Our cases also improved substantially following shunt surgery. Although there was no significant improvement in stridor in majority of adults with malignancies, their condition remained more or less stable.

The small sample size posed problems in statistical comparison of the outcomes in each diagnostic category. In such situations readily treated categories are grouped together to facilitate comparison [6]. Pediatric conditions like epiglottitis, croup and foreign body were grouped together and their outcome was compared with laryngomalacia. The former group showed a superior outcome compared with laryngomalacia ($p = 0.004$). Low pH, low PO2 and high PCO2 were associated with a poor clinical outcome ($p = 0.003$).

Key messages

Early detection of underlying acid base disorder is a very valuable step in planning management in a patient with stridor and ABG analysis holds tremendous significance as hypothesized in our aims and objectives. Our study also underlies Campbell's observation with regards to respiratory failure and its management. In short, through our study we would like to emphasize that emergency airway procedures need to be carried out, in light of blood gas analysis values instead of relying upon clinical criteria alone as is being done at various centers across the world.

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