The indications and role of paediatric bronchoscopy in a developing country, with high prevalence of pulmonary tuberculosis and HIV

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Abstract

Bronchoscopy is an important investigation in the diagnosis and management of childhood respiratory diseases widely used in high income countries. There is limited information on value of paediatric bronchoscopy in low and middle income countries (LMIC).

Aims and Objectives:

Aim of this study was to describe the indications, findings and complications of paediatric bronchoscopy in a middle income country with a high prevalence of tuberculosis (TB) and HIV.

Methodology:

A retrospective analysis of a database which included all bronchoscopies on neonates and children over a 3.5 year period (January 2010 to June 2013) in a tertiary care children's hospital in South Africa.

Results and Discussion:

A total of 509 bronchoscopies, of which 502 (98%) were fibre-optic bronchoscopies, were performed on neonates (2.3%) and children (median age = 18 months; range 1 day- 14.6 years)((male=58%) of which 5.1% were HIV-infected. The main indications were: large airway compression 40% (n = 204) complicated pneumonia (25 %) and persistent stridor (15 %). Pathology was observed in 64% (n = 319) of bronchoscopes . The most common pathology seen was lymph node compression of the airways (21%), and upper airway pathology (12%). Interventional procedures were performed in 112 cases (22%), the commonest being removing foreign bodies removal (30%), endobronchial lymph node enucleation (30%) and transbronchial needle aspiration (20%). No major complications occurred during or following bronchoscopy.

Conclusion

The diagnostic yield of paediatric bronchoscopy did not significantly differ from those reported from high income countries emphasising the importance of paediatric bronchoscopy in the management of childhood lung disease in LMICs.

Introduction

Bronchoscopy was introduced into clinical practice in 1897 by Killian.[1] Bronchoscopy is an important diagnostic tool in the management respiratory tract diseases in children. In addition to allowing direct visualization of the respiratory passages it allows for endobronchial treatment of airway lesions and collection of samples for histopathological, microbiological and cytological investigations.[2]

Bronchoscopy is not only used in removal of foreign bodies but aids in the diagnosis of congenital lung abnormalities, acquired lung pathology and has a role in the investigation of children with recurrent and or opportunistic respiratory infections.

The new generation of fibre-optic bronchoscopes, with bigger working channels, make it possible to do endobronchial interventions in young children resulting in interventional bronchoscopy being an important indication for bronchoscopy.[3] Interventional bronchoscopy has resulted in new procedures such as the sealing of trachea-oesophageal fistulas, broncho–oesophageal fistulas and post pneumonectomy stump leaks in children [3-5]. The vast majority of publications on bronchoscopy are from high income countries such as the United States, Europe and Israel [6-9]. These studies have described the bronchoscopic findings and the value of paediatric bronchoscopy in clinical and research settings in these high income countries. There is little consensus as to the indications for paediatric bronchoscopy as a survey of 220 European centres demonstrated that the indications for paediatric bronchoscopy differed according to the available instruments [8]. In centres using only fibre-optic bronchoscopes, the commonest indication was stridor (81%) while in in centres only using rigid bronchoscopy, the commonest indication was "persistent atelectasis" (68%). In centres where both rigid and fibre-optic bronchoscopes were available the commonest indication was of foreign body inhalation (93%)[8].

In addition, bronchoscopy is frequently used in the paediatric and neonatal intensive care unit (ICU) to manage complicated critically ill neonates and children.[10-12] In principle flexible fibre-optic bronchoscopy in the intensive unit does not different from those performed in an bronchoscopic suite however, conditions in the ICU demand different considerations and precautions.

As the technology evolves and the fibre optic bronchoscopes decrease in size their applicability increases in neonates and young infants. Ultrafine bronchoscopy makes bronchoscopy possible in even very small neonates and infants with critically narrow airways.[13]

There are a limited number of studies describing the use and value of paediatric bronchoscopy in low and middle income countries[14,15] especially in countries with a high prevalence of tuberculosis (TB) and HIV infections. The high incidence of respiratory infections and their complications in low and middle income countries is likely to result in the indications for bronchoscopy significantly differing from those performed in high income countries.

The aim of this study is to describe our experience in paediatric bronchoscopy over a period of 3.5 years, describing the indications, study population, bronchoscopic findings and complications of paediatric bronchoscopy and to compare the findings to those published from high income countries.

Materials and Methods

This study is a retrospective descriptive analysis of a paediatric bronchoscopy database, performed in a tertiary care children's hospital in the Western Cape, South Africa. The

Western Cape is a region of South Africa with a TB incidence of approximately 1% and a HIV prevalence of 16 %.

All patients less than 15 years undergoing bronchoscopy were entered into an established paediatric bronchoscopy database between 1st January 2010 and the 30th June 2013 were included. Excluded patients included those with incomplete or missing data. The following data was available for analysis: patient demographics, indication for bronchoscopy, findings at bronchoscopy, location where the bronchoscopy was performed, type and size of bronchoscopy used, interventions performed as well as the complications that arose during or immediately following the bronchoscopy.

The data was entered onto case report form (CRF), transcribed into an anonymised database and analysed using STATISTICA (data analysis software system), by StatSoft, Inc.

The Human Research Ethics Committee of the Faculty of Medicine and Health Sciences, Stellenbosch University (**S13/08/141**), approved the study.

Results

Bronchoscopy was performed on 509 (male = 58%) neonates, infants and children with a median age of 18 months (range 1 day - 14.6 years) of which 43% were between 13 and 36 months.

The main indications for bronchoscopy were (table 1) : large airway compression 40% (n= 204) complicated pneumonia 25 % (n = 126), persistent stridor 15 % (n = 78), suspected foreign body aspiration 7% (n = 35) , persistent wheezing 5% (n= 26) and interstitial lung

disease 4% (n =20). The majority of children investigated for complicated pneumonia had recurrent pneumonia (n = 114) .

Tuberculosis was the commonest cause of large airway obstruction 20.8% (n= 105). Other common causes of airway obstruction were mucus plugs causing lung or lobar atelectasis (n= 49) and vascular compression of the central airways (n = 35) (see Table 2). The commonest vascular causes of large airway obstruction were a double aortic arch (n =10) and an anomalous innominate artery (n = 10). Others vascular causes included a left pulmonary sling (n= 7), aberrant subclavian artery (n = 7), and patent ductus arteriosus (n = 1).

Stridor was an indication for bronchoscopy in 15% (n = 78) of patients. Laringomalacia (38%) and subglottic stenosis (33%) were the commonest causes of stridor identified. Vocal cord paralysis and a subglottic web were each diagnosed in 4 cases. In neonates, less than 1 month of age, the commonest indication for bronchoscopy was failed extubation due to upper airway obstruction presenting clinically with stridor 58.3% (n = 12).

Twenty six (5.1%) were HIV–infected patients with a median age of 39 months (range of 3 months to 11 years) The commonest indication was suspected TB lymph node compression of the airways 42% (n = 11) which was more common HIV-infected children when compared to HIV uninfected children (P= 0.01). In HIV infected children *Haemophilus influenzae* was also more commonly cultured from BAL (p = 0.04) when compared to BAL samples from HIV-uninfected children. The indications and bronchoscopic findings in the HIV-infected children are listed in Table 3.

The majority of the bronchoscopes were done in bronchoscopy theatre 78% (n = 395) followed by the PICU (13%) and NICU (5%). In the PICU the median age of the children

were 21months (range 1 month – 12 years). In the PICU the commonest indication was upper airway obstruction following failed extubation in 64% (n = 43) with the commonest cause of the upper airway obstruction being subglottic swelling (25%). Twenty four (4.7%) of bronchoscopes were performed in the NICU with a median age of 43 days (range 2 days – 5 months). Similar to the PICU the commonest indication was failed extubation due to upper airway obstruction (71%) with subglottic swelling the commonest finding (47%).

Intra operative bronchoscopy was done in the cardiothoracic theatre in 4% (n = 22). In this setting intraoperative bronchoscopy was used to assess the optimal surgical response during an aortapexia in children with vascular obstruction of the airways.

A flexible bronchoscope was used in the greatest majority of cases (98.6%) with rigid bronchoscopy only used in 1.4% of cases, all following foreign body inhalation. Of the flexible bronchoscopes the 2.8 mm video bronchoscope was used in 67% (n=344) followed by the 4.0 mm video bronchoscope scope with a 2 mm working channel in 25% (n = 127)). The ultrafine neonatal bronchoscope was used in 3% (n=16) of neonates and children to assess critical airway narrowing.

Pathology was observed in 64% (n = 319) of bronchoscopes (Table 2). The most common pathology seen was lymph node compression of the airways (21%), and upper airway pathology (12%). In the group with upper airway pathology, subglottic stenosis was the commonest finding (43%).

Broncho-alveolar lavage (BAL) was performed in 451 (88.6%) patients. Of the 105 children bronchoscoped for suspected TB compression of the airways *Mycobacterium tuberculosis* were cultured or demonstrated by molecular diagnostic techniques (Gene Xpert MTB-Rif

(Xpert; Cepheid, CA, USA) in 98 (93%) of the cases. In 57 (58%) of these cases both the *Mycobacterium tuberculosis* culture and the Gene Xpert test were positive while in 39 cases only the culture for *Mycobacterium tuberculosis* was positive. In 2 patients the *Mycobacterium tuberculosis* culture was negative while the Gene Xpert was positive. Direct microscopy for acid fast bacilli was positive in 42 (43%) of cases, all of whom were *Mycobacterium tuberculosis* culture positive. In the 7 (6.7%) cases where both the culture and the Gene Xpert were negative the bronchoscopic image of TB lymph nodes ulcerating into the large airways was highly suggestive of TB. In HIV-infected children with lymph node compression of the airways (n=11) *Mycobacterium tuberculosis* was cultured in 9 cases of which 8 were also Gene Xpert positive.

In addition to the isolation of *Mycobacterium tuberculosis* another organism was isolated from 107 (23.7%) of the BAL samples. In the majority of these 107 samples more than one organism was isolated. In 65.4% (n = 70) more than one virus was identified and in 34 (31.8%) a combination of a virus and bacterium was found. In those patients who were culture positive for *Mycobacterium tuberculosis* a virus was also isolated form the BAL; the commonest virus being Cytomegalovirus (CMV) in 16%. In the 11 (5.4%) culture positive for *Mycobacterium tuberculosis* bacteria were also cultured: the commonest being Haemophilus influenza 3.4% (n= 7). Results of BAL are seen in table 5.

One hundred and twelve bronchoscopic interventions were performed. (Table 6) The commonest interventions was foreign body removal in 30% (n= 35) with 89% removed via a flexible bronchoscope; the 4.0 mm flexible videoscope used in 54% of the cases. The median age of this group was 5 years 9 months (range 9 months – 12 years). The commonest location of foreign body were; right main bronchus (48.6%), left main bronchus (25.7%) and bronchus intermedius (14.3%). In 86% of cases the foreign bodies were either inorganic or plastic

material. Of those children that inhaled plastic material (n=16) 6 were cheap plastic whistles bought in a packet as a combination of cheap toys and sweets. Only one peanut was removed during the study.

The second commonest intervention was endoscopic enucleation of lymph nodes ulcerating into the airways. In 35 (30%) children with severe airway obstruction due TB lymph node compression and ulceration into the airways endoscopic enucleation was required to restore airway patency. The next most common intervention was transbronchial needle aspiration of intrathoracic lymph nodes (TBNA). TBNA was performed in 22 (20%) children with enlarged mediastinal lymph nodes allowing the diagnosis to be made in 27.6% of the cases. Other interventions included endobronchial biopsy in 9% (n = 10), aiding endoscopic intubation in 7% (n = 8) and the sealing of two cases of acquired broncho –oesophageal fistula due to TB with human fibrin glue. These fistula mostly develop between the left main bronchus and the oesophagus due to TB lymph nodes which cause a erosion between these to structures leading to chronic aspiration or acute respiratory distress.[15]

Complications were noted in 10 (1.9%) of the 509 scopes performed. The commonest complication being a hypoxic event (n =6) where the patients had desauturations below 80% and bronchoscopy had to be temporary interrupted , all of these children did recover from hypoxia and bronchoscopy completed. Self-limiting bleeding (n =2) were seen in children in which TBNA were preformed. Reversible bronchospasm was seen in one child , needing PICU care for 24 hours and recovered on bronchodilator therapy and intravenous corticosteroids.

Discussion

In this study paediatric bronchoscopy in a LMIC bronchoscopy was shown to be a valuable tool to diagnose and manage complicated respiratory disease in neonates and children. The indications for bronchoscopy in this study performed in a middle income country were similar to those published from high income countries with the exception of TB lymph node compression of the airways. The indications and findings in HIV-infected and uninfected children were similar except for tuberculosis(TB) lymph node compression of the airways which was more common in HIV-infected children. Interventional bronchoscopy, made possible by larger working channels in paediatric flexible bronchoscopes, played an important part in removing inhaled foreign bodies, enucleating lymph nodes obstructing large airways and performing diagnostic transbronchial needle aspiration (TBNA). The study reports a unique finding concerning the high diagnostic yield (93%) to confirm *Mycobacterium tuberculosis* in children suspected of having airway obstruction due to TB lymph node compression of the airways.

In this study the main indications for bronchoscopy were: large airway obstruction mostly because of TB (21%) and complicated pneumonia (25%) . Godfrey et al published a study on the utility of flexible bronchoscopy in children, examining 200 consecutive procedures[9] . The main indications in that study were wheezing (26%), recurrent pneumonia (21%) and atelectasis (12.5%). Gibson et al, presented a series of fibre-optic bronchoscopy in patients under 10 kg[16]. In this case series the main indication for bronchoscopy was stridor (14%) and lobar atelectasis (9.6%) [16]. In a study examining a decade of in which 536 fibre-optic bronchoscopy were performed on children younger than 14 years the most common indications were persistent atelectasis (31%), stridor (25%), tuberculosis (12%), suspected foreign body (11%) and persistent wheezing (10%) [17].

In a multicentre European study of 51 centres, questionnaire were sent to specialists from different countries. Approximately 40% of the centres responded allowing data to be gathered concerning 4,587 flexible bronchoscopies in European children. The primary diagnosis diagnosis prior to bronchoscopy were recurrent or persistent pneumonia (17%), followed by wheezing unresponsive to treatment (15.5%), persistent atelectasis (14%) and stridor (13%). [8] The findings at bronchoscopy of our study were in keeping with reports in the literature from mostly high income countries with normal anatomy noted in (21.6%) of bronchoscopes, inflammation of the airways (14%), subglottic stenosis (4.4%) and foreign body aspiration (7.0%). The notable expectation was TB lymph node compression of the airways which occurred in 21% of cases.

Our study was performed in one of the 22 tuberculosis high burden countries where 95% of childhood tuberculosis occurs. The situation is further exacerbated by the high HIV prevalence in Southern Africa. The institution from where this study originates is a tertiary care children's hospital to which children with complicated tuberculosis or combined TB-HIV are referred. It is from this patient population that children requiring bronchoscopic evaluation arise, especially those with symptomatic TB lymph gland compression of the airways. [15] What is however surprising that in this group of children the diagnostic yield confirming TB as the cause of the enlarged lymph nodes was 93%. This diagnostic yield was similar in HIV-infected and uninfected children. The possible reasons for the high diagnostic yield were the extensive use of BAL, the application of transbronchial needle aspiration [18] and the use of both *Mycobacterium tuberculosis* cultures and lately the use of molecular diagnostic methods (Gene Xpert MTB-Rif (Xpert; Cepheid, CA, USA). The reported diagnostic yield is not higher than has previously reported in children with expansile pneumonia caused by Mycobacterium tuberculosis (88%) [19] but considerably higher than other studies that used BAL samples for Mycobacterium tuberculosis culture only (44%) [15].

BAL Gene Xpert MTB-Rif increased the diagnostic yield on BAL samples by 14% [20]. In the 7 children where the isolation of Mycobacterium tuberculosis failed the bronchoscopic image of the TB lymph node ulcerating into the airway was highly suggestive of TB adding an additional reason why bronchoscopy was useful in children with suspected TB. In addition to confirming the diagnosis of TB intervential bronchoscopy played an important role in performing endoscopic enucleation of TB lymph nodes that had ulcerated into the airways causing critical airway narrowing.

Bronchoscopy in TB is not only important in isolating the causative organism but also allows for the evaluation of the degree and site of airway compression due to TB lymph node enlargement. The major sites of airway compression in childhood TB is bronchus intermedius, left main bronchus and the trachea[15]. Airway compression is more severe in children younger than 24 months [15]. Bronchoscopy does not only confirm the diagnosis but provides a functional and anatomical evaluation of the airway involvement in pulmonary TB, which in addition to raising the suspicion of TB lymph node compression of the airway also guides treatment [21].

This study also emphasises that TB lung disease is possibly complicated by additional virus and bacterial infections with Cytomegalovirus (CMV) and H. influezae being the commonest organisms isolated. CMV was more commonly isolated in HIV-infected children (47%). The significance of these organisms remains unexplored.

South Africa is a middle income country with a high prevalence of HIV and TB both in children and adults, it was therefore surprising that only 26 patients (5.1%) were confirmed HIV positive. A possible explanations for this lower than expected HIV-lung disease requiring bronchoscopy was the highly successful prevention of mother to child transmission

of HIV program (PMTCT) in South Africa and the early introduction of ante-retroviral therapy in infants irrespective of their blood CD_4 counts or HIV viral load [22].

Bronchoscopy does not only have a diagnostic purpose but has become an important tool in the management of many respiratory conditions. It has been used as a tool to measure response to treatment especially in conditions affecting the large airways.[15] In these situations bronchoscopy may be a better tool than chest computer tomography as dynamic changes of the airway can be observed during spontaneous breathing while having the added benefit of not radiating the child and allows for the collection of diagnostic specimen. In our experience the 2 investigations supplement each other.[23]

The most common indication for bronchoscopy has been to use the bronchoscope as a diagnostic instrument. During the last number of years a number of articles have been published on using the bronchoscope to perform various interventions [3]. Initially all the interventions were performed via the rigid bronchoscope but recently as larger working channels in fibre-optic bronchoscopes became available the more procedures are performed via the flexible bronchoscope [3,24]. Common interventions performed in children via the flexible bronchoscope include removal of foreign bodies and mucus plugs, endobronchial and transbronchial needle aspiration biopsies, assistance with endotracheal intubation including selective intubation, lung lavage for alveolar proteinosis, selective placement of endobronchial catheters, airway dilatation and for the sealing of trachea-bronchial fistula using fibrin glue [3-5]. The number of intervention on children performed globally is unknown and effectiveness of these interventions is uncertain as no randomised control trials have been performed. In this study 112 bronchoscopic interventions were performed, the most common being foreign body removal and endoscopic lymph gland enucleation of TB lymph nodes causing critical airway obstruction. Endoscopic decompression of lymph nodes is not well

described. This is mostly used in two different situations. Some children present with severe airway obstruction where the TB lymph nodes have herniated into the airway and causing severe airway obstruction. In an emergency situation it is necessary to re-establish airway patency. This can either be done with rigid bronchoscope or flexible bronchoscope. Rigid scope by be more effective due to the size of biopsy forceps that can be used . The limitation is in young children where the trachea is very narrow due to external compression and the obstruction in in the main bronchi. In this situation a flexible scope can be use with the aid of a biopsy forceps and the caseating material remove. This may be a time consuming intervention but the aim is not to remove all the tissue but only to repair airway patency. The risk is bronchus wall rupture if too much tissue is removed, It is common practice to repeat this intervention 2 weeks later rather than to be too over jealous and causing bronchus wall injury. In the majority of cases where endoscopic enucleation was performed the TB lymph nodes had ulcerated into the airways. All the interventions were via a fibre-optic bronchoscope except for 4 cases where a rigid bronchoscope was used to remove an aspirated foreign body. Nicolai found that 78.6% of foreign bodies could be extracted with flexible bronchoscopy but cautioned that provisions need to be in place to switch to rigid bronchoscopy should the need arise [25]. In spite of three quarters of foreign bodies being removed via a flexible bronchoscope the author still recommend that rigid bronchoscopy is the preferred procedure for the removal of aspirated material; however in cases where foreign body aspiration is part of the differential diagnosis and patients have no history of foreign body aspiration, flexible bronchoscopy is preferred [25]. This study further indicates the necessity of having the skills to perform interventions via the bronchoscope in LMIC, where the skills are sadly lacking and where training is urgently required [26].

The complication rate was extremely low (1.9%), with the commonest complication being a hypoxic event, in which there was a brief period of desaturation to less than 80% saturation.

This is similar to the complications reported in a review of 1,328 paediatric bronchoscopes with minor complications occurring 5.2% (transient episodes of desaturation, excessive coughing, laryngospasm transient) and 1.7% experiencing major complications, such as moderate or severe desaturation and bronchospasm [27].

Limitations:

This was a retrospective study of a highly selective cohort of referred children to a tertiary care facility. The proportion of cases with TB lymph node compression of the airways will differ in other LMIC settings as this study was carried out in a referral children's hospital in a region with an extremely high prevalence of pulmonary tuberculosis and HIV-infection. The high diagnostic yield is possibly due to the high proportion of children with complicated TB requiring investigation. Children with complicated TB are more likely to have a high bacillary load, as reflected in the 35% of the respiratory samples being Ziehl-Neelsen (Z-N) stain positive unlike most uncomplicated childhood TB which is Z-N stain negative due the paucibacillary nature of the disease. The low prevalence of the HIV-related lung disease (5%) could possible make us underestimate the bronchoscopic images and diagnostic yield in this sub-group of patients.

Conclusion

The study demonstrated that bronchoscopy is an important diagnostic tool in the management of complicated lung disease in children living in LMICs. Except for TB lymph node compression of the airways indications for bronchoscopy did not differ from those published in the high income countries. The study further highlights the need for paediatric bronchoscopy as a diagnostic tool and intervention instrument for investigating and managing neonates and children with complicated respiratory disease in LMICs. Further studies are required on the use of paediatric bronchoscopy from other LMICs.

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Table 1: Indications for Bronchoscopy

Indication	**Number**	
Large airway compression	n = 204	40%
Complicated pneumonia	n = 126	25%
Stridor	n = 76	15%
Foreign body aspiration	n = 35	7%
Persistent wheeze	n = 28	6%
Interstitial lung disease	n = 20	4%
Endoscopic intubation	n = 8	2%
Caustic ingestion	n = 6	1%
Bronchiectasis	n= 6	1%

Table 2 : Findings at bronchoscopy

Finding	Number	Percentage
1. Normal anatomy	182	36
2. TB nodal compression	105	20.6
3. Foreign body	35	7.0
4. Vascular anomaly	35	6.9
5. Structural anomaly	32	6.3
6. Subglottic stenosis	22	4.4
7. Omega epiglottis	14	2.8
8. Granulation tissue	12	2.4
9. Laryngomalacia	11	2.1
10. Alveolar proteinosis	11	2.1
11. Pulmonary haemorrhage	8	1.5
12. Tracheomalacia	7	1.4
13. Tracheitis	5	1.0
14. Subglottic web	4	0.8
15. Vocal cord paralysis	4	0.8
16. Tracheo-oesophageal fistula	4	0.8
17. Granuloma vocal cords	3	0.6
18. Cobble stone oedema	3	0.6
19. Congenital cyst	2	0.4
20. Virus papilloma	2	0.4
Total	**501**	

** 8 scopes where performed for Endoscopic intubation

Table 3 Indication and findings of scopes in HIV positive patients

Indication	**Findings**	**Number**	**Percentage**
Large airway obstruction	TB Nodal compression	11	42.3
Recurrent pneumonia	Normal anatomy	3	11.5
	Inflammation airways	3	11.5
	Pus in airways	2	7.7
	Mucus Casts	2	7.7
Stridor	Vocal cord paralysis	1	3.8
	Supraglottic oedema	1	3.8
Failed Extubation	Subglottic narrowing	1	3.8
Interstitial lung disease	Normal anatomy	1	3.8
Bronchiectasis	Collapse RLL, LLL	1	3.8
Total		**26**	

Table 4 : Indication and finding of scopes performed in PICU

Indication	Finding	Number
Failed Extubation	Subglottic swelling	11
	Inflamed airways	8
	Pneumonia due TB	6
	Swollen floppy epiglottis	5
	Thick secretions/pus	4
	Laryngo/Tracheomalacia	3
	Omega epiglottis	2
	Subglottic stenosis	2
	Granuloma vocal cords	2
Severe LAO	Nodal compression	5
	Tracheitis	3
Difficult intubation	Cystic Hygroma	2
Difficult ventilation	Normal anatomy	11
Caustic ingestion	Sloughing of mucosa	3
Total		**67**

Table 5: Organisms isolated from broncho-alveolar lavage (BAL)

Type	**Organism**	**Number**	**Percentage**
1) Bacteria	Haemophilus Influenzae	7	33.3
	Streptococcus Pneumoniae	4	19.0
	Klebsiella Pneumoniae	3	14.3
	Acinetobacter	2	9.5
	Pseudomonas aeruginosa	2	9.5
	Citrobacter	1	4.8
	Staphylococcus aureus	1	4.8
	Proteus mirabilis	1	4.8
Total		**21**	
2) Viruses	Cytomegalovirus	55	64.7
	Rhinovirus	11	12.9
	Adenovirus	6	7.1
	Parainfluenza virus	5	5.9
	Metapneumovirus	4	4.7
	Respiratory syncytial virus	2	2.3
	Coronavirus	1	1.2
	Enterovirus	1	1.2
Total		**85**	
3) Fungi	Peumocystis jiroveci pneumonia	**1**	

Table 6: Interventional procedures

Type	Number	Percentage
Foreign body removal	**35**	**30**
Endoscopic Enucleation	**35**	**30**
TBNA	**22**	**20**
Endobronchial Biopsy	**10**	**9**
Endoscopic intubation	**8**	**7**
Closing of fistula	**2**	**2**
Total	**112**	