Thoracoscopic treatment of congenital malformation of the lung
Preliminary experience with preoperative 3D virtual rendering

F. Destro M. Maffi T. Gargano
G. Ruggeri L. Soler M. Lima

Table of Contents

1. Contents ........................................................................................................ 1
   1.1. ABSTRACT ........................................................................................ 1
   1.2. INTRODUCTION ................................................................................ 2
   1.3. MATERIALS AND METHODS ............................................................. 2
   1.4. RESULTS ........................................................................................... 3
   1.5. DISCUSSION ...................................................................................... 3
   1.6. CONCLUSIONS .................................................................................. 4
   1.7. REFERENCES .................................................................................... 4

1. Contents

1.1. ABSTRACT

Introduction: Congenital malformations of the lung (CML) are rare but potentially dangerous congenital malformations. Their identification is important in order to define the most appropriate management.

Materials and methods: We retrospectively reviewed data from 37 patients affected by CML treated in our Pediatric Surgery Unit in the last four years with minimally invasive surgery (MIS).

Results: Prenatal diagnosis was possible in 26/37 patients. Surgery was performed in the first month of life in 3 symptomatic patients and between 6 and 12 months in the others. All patients underwent radiological evaluation prior to thoracoscopic surgery. Images collected were reconstructed using the VR render software.

Discussion and conclusions: Volume rendering gives high anatomical resolution and it can be useful to guide the surgical procedure. Thoracoscopy should be the technique of choice because it is safe, effective and feasible. Furthermore it has the benefit of a minimal access technique and it can be easily performed in children.
1.2. INTRODUCTION

Congenital malformations of the lung (CML) is a group of anomalies potentially harmful both during pregnancy and after birth. Despite the increasing knowledge about these lesions, many aspects concerning the pre and postnatal management remain unclear (1-3). Many authors suggest that the surgical approach is mandatory in order to avoid potential complications (infections, malignancies and respiratory symptoms). The timing is still discussed. The thoracoscopic approach permits a safe pulmonary resection with fast recovery and better esthetical results. It is however important to differentiate the different types of CML prior to surgery. Bi-dimensional studies are useful especially in the evaluation of the vascularization. The development of new software for 3D reconstruction adds other anatomical details. 3D imaging can be used along with classic radiological studies and represents a sort of first step to the realization of the interactive augmented reality in the operative room.

The aim of this study is to describe our experience with the use of preoperative VR renders of CML treated by thoracoscopy.

1.3. MATERIALS AND METHODS

We perform a retrospective study in our Department of Pediatric Surgery from January 2008 to January 2012 of all children treated by thoracoscopy for CML. Data include: sex, age at surgery, prenatal diagnosis, clinical and radiological features, surgical procedure, histological findings and complications.

VR Rendering

VR rendering is a well known visualization method for the 3D reconstruction of medical images. We used the software VR render. It is an IRCAD image view software that allows to visualize bidimensional images in 3D thanks to volume rendering. It works with CT scans and MRI images. It is based on transparencies and coloration of voxels. Indeed a medical image is composed by a set of voxels that is a pixel in 3D. By given a specific coloration to each voxel we obtain a new 3D image with magnification of anatomical details. It is also possible to manipulate the volume rendering view using clipping plane in order to focus on the lesion.

Technique

Fig. 1

The procedures were performed with the patient in the lateral decubitus position (Fig. 1). The surgeon and the assistant were at the patient’s front with monitors at the patient’s back. When it was possible, for older patients, a double lumen endotracheal tube was used for single lung ventilation. Initial procedure was performed using a combination of three or four thoracoscopic ports. The first 5 mm trocar was generally placed in the 5th intercostal space in the middle axillary line and it was used to create pneumothorax with low CO2 pressure to help complete collapse of the lung. A flow of 0.5 L/min and a pressure of 4 – 6 mmHg is maintained. A 0° 5 mm optic with an image – 1 (Storz) camera was used. Other 3 – 5 mm trocars were placed under direct vision according to the position of the mass. Two Joanne devices were used for the manipulation of the parenchyma and an armonic scalpel or Ligasure was used for coagulation. In most cases an atypical resection (sparing surgery) with EndoGIA was performed.
Fig. 2a,b

The EndoGIA device requires the position of a 10 mm trocar. In case of pulmonary sequestration we used a PDS endo – loop (Fig 2a,b) or a mechanical suture (Fig 3a,b) for the ligature of the vessels. The extraction of the dissected mass was possible with an enlargement of the trocar site. When it was necessary a conversion to open surgery a mini thoracotomy was performed using a total muscle – sparing technique. At the end of the procedure one or two chest tubes were left in all cases.

1.4. RESULTS

Over a 4 years period 37 patients (20 males and 17 females) were diagnosed with CML. The mean age at surgery was 9.2 months (range 15 days and 11 years). 26/37 patients (70%) were diagnosed during prenatal ultrasound evaluation. At birth 3/37 (8%) had respiratory distress and they underwent to surgery in the first month of life. Older patients (2/37 = 5%) presented with recurrent respiratory infections. The diagnosis was made preoperatively by either X – ray, US scan with Doppler and Angio CT scan. We also performed 5 MRI studies to evaluate 5 patients with an unclear diagnosis of pulmonary sequestration. All the radiological bidimensional images were converted with the VR render. Patients were treated with a thoracoscopic approach. The surgical procedure consisted in 33/37 (89%) atypical sparing resections, 3/37 (8%) pulmonary segmentectomies and 1/37 (3%) lobectomy. The histological examination differed from the radiological preoperative diagnosis in 6/37 (16%) cases, in particular 6 pulmonary sequestrations (one of them was a necrotic PS, rotated on his supply vessel) were misdiagnosed as CCAM. 15/37 procedures (40%) were converted to mini thoracotomy and no postoperative complications occurred.

1.5. DISCUSSION

In literature the management of CML is debated. We believe that early surgical approach (in the first month of life) is indicated when the patient is symptomatic. If there are not clinical symptoms surgery can be postponed from 6 to 12 months, because it is easier in older children to make differential diagnosis and when the child is grown up surgical and anesthetical risks are reduced (ref.4-10). The resection of these lesions prevent the arise of pulmonary infections, pneumothorax and the development of malignancies (ref.11-13). In addiction some authors advocate the possibility to have a compensatory pulmonary growth after early surgery (ref.14). Furthermore infection of the mass is a common sequelae that increases the incidence of intra and postoperative complications. In our institution the most used surgical technique is the wedge or atypical resection.

In presence of a CCAM the wedge resection can be performed in order to preserve functional parenchyma. The excision of extralobar PS requires the legation of the supply blood vessels (Fig 3) and the excision of the sequestration alone ( ref.15 ) . The procedure is easily performed if the vascularisation has been previously well defined by preoperative radiological
studies. Intralobar PS needs the removal of lung parenchyma that can be achieved with wedge resection while CLE is generally removed by lobectomy [9,16,17]. Other endovascular methods are described in literature but many authors believes that they expose the patient to higher risks (infections, embolization, recurrences …). Thoracoscopy is widely performed in children and it is an efficient, safe and feasible method [18].

Preoperatively the use of 3D reconstructions provides unique insights into the anatomical architecture of the malformation and allows to define the relationship with adjacent structures. Lee and colleagues concluded that volume rendering, compared to CT, permits to identify the venous drainage of PS resulting in the differentiation of intra and extralobar forms and in the most appropriate surgical procedure [19, 20]. In our opinion VR render is also useful to distinguish the borders of the pleura thus differentiating the two types of sequestration (intra and extralobar). The following figures show some reconstructions of EPS (extralobar pulmonary sequestration) made from both CT and MRI scans. VR render images permit to appreciate the vascularisation, the anatomical borders and the connection with the pleura. In particular in Fig. 4b is well shown the arterious vessel, arising from the descendant aorta supplying the sequestered lung. Changing the parameters of reconstruction (Fig. 4c) it is possible to appreciate a triangular postero–basal mass near to the column. The mass is separated from the tracheobronchial tree and it has its own coat, without involvement of the pulmonary pleura. The normal pleura is shown as a well defined line surrounding the parenchyma (blue arrows). There is also the possibility to rotate the model in order to have different point of views (posterior, lateral, inferior …). Another case of PS is shown in Fig. 5. This patient had a pulmonary mass with multiple supply arterious and venous vessels that were identified with reconstructed images. Fig 6a represents a right posterior mediastinic cyst near the omolateral principal bronchus. The VR render improve the visualization of anatomical relationships of the cyst with surrounding structures (Fig 6b). The cyst appears to be filled by fluid and separated from the parenchyma (Fig 6c). In Fig. 7a,b,c is shown the radiological aspect of a congenital cystic adenomatoid malformation (CCAM). The mass appears to be located in the inferior left lobe. VR render shows multiple cysts filled by air and a solid area in the posero – inferior segment.

All cases studies with VR render permit to confirm the diagnosis made with standart CT and MRI scans and give to the surgeon a better comprehension of the anatomical details.

1.6. CONCLUSIONS

CML are malformations that may require early surgical resection in order to avoid infections or malignancies. Thoracoscopy is a safe and useful procedure for the treatment of CML and it can be used also in paediatric population. An appropriate preoperatory evaluation is mandatory in order to plan the surgical procedure. CT and MRI are the gold standard in the evaluation of these patients. The use of VR render has extended the potentialities of CT and MRI. The advantages of this technique are a better anatomical definition, especially regarding vascularisation and precise and detailed localization. Even if VR render can’t be defined as the best technique we believe that advantages can be achieved by using standard CT/MRI scans together with reconstructed images.

1.7. REFERENCES


Fig. 1 Position of the patient during thoracoscopic surgery

Fig. 2 Thoracoscopic resection of a pulmonary sequestration: after the use of the endoloop (a) the vascularisation to the sequestered lung is interrupted and the parenchyma changes its colour (b).

Fig. 3

Fig. 4 CT scan of an extralobar pulmonary sequestration (a) and the reconstructed images (b,c). Blue arrows show the pleura, green arrow shows the afferent systemic vessel to the sequestered lung.

Fig. 5 Prior to surgery the patient underwent to radiological studies to evaluate the lung mass (red arrow in a). Multiple vessels are identified in Angio MRI scans (b). The use of VR render confirms the presence of arterious branches coming from the aorta (green arrows in c). The mass is approached thoracoscopically (d).
Fig. 7 Aspect of cystic adenomatoid malformation in CT scans and reconstructions (a,b,c). Multiple cysts are seen also during thoracoscopy (d).

Fig. 6 Aspect of broncogenic cyst in CT scans and reconstructions (a,b,c). The lesion appearance during surgery (d). Notice how the pleura is well marked (blue arrow in c).