Application of Computer Navigation-assisted Thoracoscopic Surgery in Resection of Rib Tumor

Q Zhang, L Song, S-N Ning, H Xie, Y-B Wang

ABSTRACT

Objective: Excision of rib tumors by conventional surgical method often results in poor prognosis due to trauma and heavily bleeding. In the present study, we evaluated the advantages of applying computer navigation-assisted thoracoscope in the resection of rib tumors.

Methods: Prior to surgery, the pathology bearing regions of rib tumors in 4 patients were scanned by computer tomography (CT) and the surgical margin was predetermined. During operation, the fusion image of 3-dimensional navigation scanning and CT clearly provided the guidance for the resection of rib tumor by minimally invasive thoracoscopy techniques.

Results: Postoperative specimens demenstruated that a safe border was observed and the tumor specimen margin was negative based on histological study. Combination of computer navigation technique and thoracoscopy could assist surgeons to more accurately judge the tumor margin, implement minimal invasive resection, and minimize the trauma of patients.

Conclusion: Based on our clinical experiences, the combined surgical method is especially feasible for the tiny tumor or some tumors that are unreachable or resided in scapula and deep face of breast.

Keywords: Chest, computer applications, surgical equipment, thoracoscopy

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INTRODUCTION

Primary chest wall tumors are reported only rarely, accounting for 0.04% of new tumors and 5% of thoracic neoplasims (1-3). The rib tumors are a kind of primary chest wall tumors, and it accounts for the 50% of malignant or benign bony tumors of the chest wall and the 5 - 7% of all primary bone neoplasms (1, 4). Chemotherapy and radiotherapy are accepted methods to treat the rib tumors, but the prognosis is not favorable (5). So, the excision for the tumor is generally needed. However, the conventional surgical method often causes large trauma and is commonly accompanied by heavy bleeding. For those small tumors or tumors with complex anatomic structure, it is challenging to determine the surgical field. Resection of tumors by minimally invasive thoracoscopy (MIT) and computer navigation scanning system can maximally preserve the structure of chest wall and avoid postoperative complications. In the present report, we reported the application of computer navigation-assisted MIT in the resection of the rib tumors and presented our experiences in minimally invasive treatment of bone tumors.

SUBJECTS AND METHODS

Clinical data

Since January 2014, the computer navigation-assisted thoracoscopic surgery has been applied in the chest surgery of our hospital (Beijing Jishuitan Hospital). In the present report, 4 patients including 3 males and 1 female were involved. Their ages ranged from 30 to 49 years with average age of 41.5. One patient had no symptoms, and the other three patients had medical history of chest pain. Bone scanning results showed regional hard tissue density. The clinical

data and pathological diagnosis results were listed in Table 1. This study was approved by the Ethics Committee of the Beijing Jishuitan Hospital.

Instruments

The infrared-inducing navigation system was obtained from Stryker (Stryker, Carat su, Michigan, USA). The Orthomap 3D Navigation system was applied to these four patients. LTF-240 thoracoscopy was provided by Olympus (Olympus, Japan).

Surgical procedure

Before the operation, computer tomography (CT) images were imported into the navigation working station to ascertain and label the pathology bearing regions for resection.

After intravenous inhalational anesthesia, double-cavity tracheal cannulas were applied to patients lying on the health side and thorascoscopy was placed into the 7th intercostal space at the axillary midline. Then, the patient tracer was driven into the sternum or the ribs neighboring the pathological rib (Fig. 1), and the patient tracer, pointer and C-type arm were registered successively. After registration, 100 digital X-ray images were collected during automatic continuous rotation (190^{o}) followed by automatic 3-dimensional reconstruction (Fig. 2). The C-type arm was connected with the navigation workstation and the image data was transferred to navigation system for automatic registration, and thereafter the navigation-assisted surgery could be initiated.

Fig. 1: Registration of patient tracker.

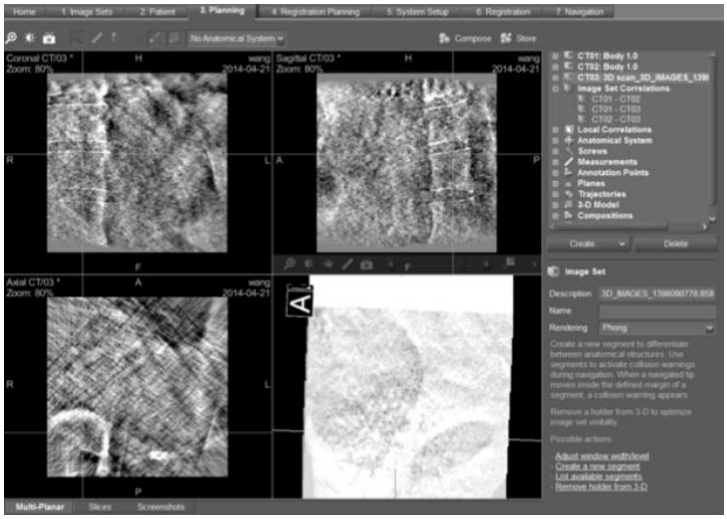

Fig. 2: Images scanned by C-type arm.

The CT image data (CT-1) obtained from pre-operation was fused with the data (CT-2) reconstructed by the C-type arm by matching the markers. The 3 - 5 sectional anatomy faces with 4 points on each sectional anatomy face were selected for image fusion (Fig. 3). The fused image was then transferred to the navigation system. Then, the surgical region was observed by interchangeably observing the CT-1 and CT-2 data.

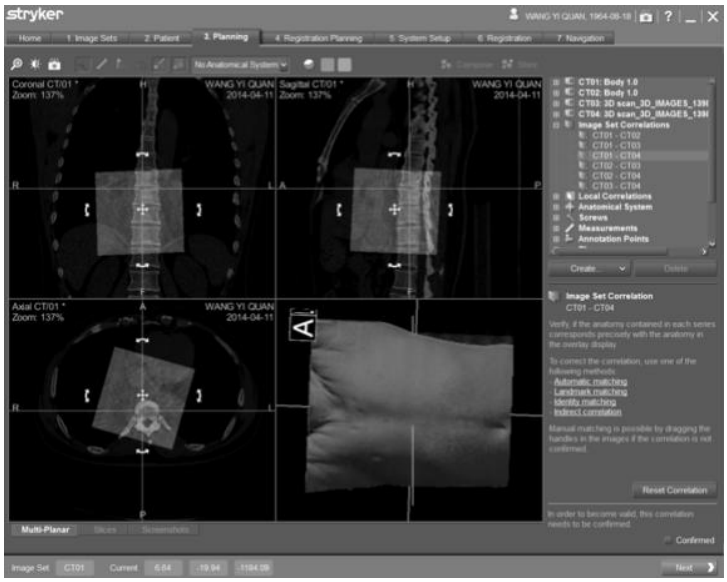

Fig. 3: Fusion of images obtained by C-type arm scanning and CT scanning.

The main operation hole usually localized at the 3rd, 4th or 5th intercostal could be determined according to the accurate pathology bearing locus under the guidance of the pointer (Fig. 4). Meanwhile, an auxiliary operation hole was made at the subscapularis corner. Steel wire saw was used to saw off both ends of the ribs. The wound bleeding was stopped and no internal fixation was needed (Fig. 5 and 6).

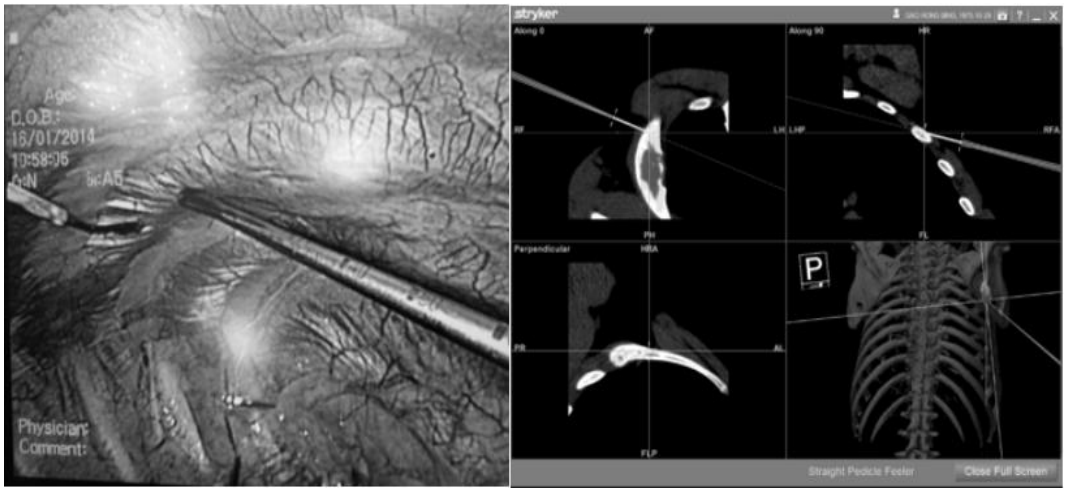

Fig. 4: Ascertain of the surgical region under the guidance of patient tracker.

Fig. 5: Resection of rib tumors with the help of thoracoscopy.

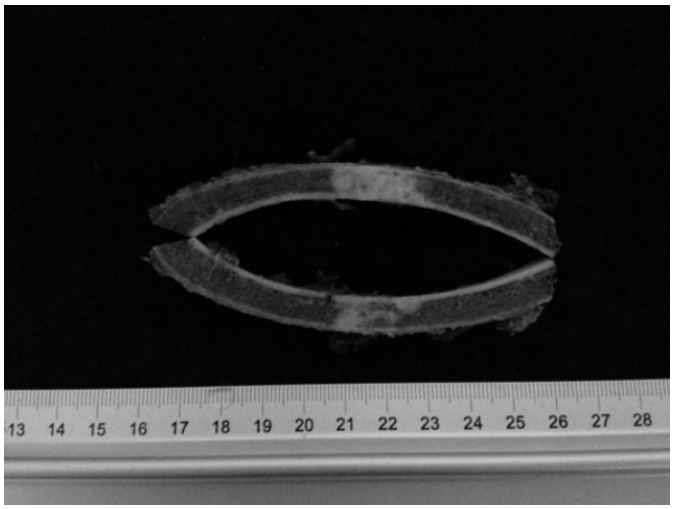

Fig. 6: Rib specimens after resection.

RESULT

The rib tumors in the 4 patients were successfully resected by the navigation-assisted surgery, and the scanning and fusion averagely took 67.7 min. After surgery, the pathological diagnosis results approved that the rib tumors in three patients were benign while the other one was solitary extramedullary plasmacytoma. Patients did not have the symptom of chest pain and the recurrent tumors were not observed for them in the next six-month follow-up.

DISCUSSION

The surgical approach for rib tumors depends on whether it is benign or malignant. Some symptoms such as the clear boundaries of tumor by palpation and no obvious pain highly indicate that the tumor may be benign lesion, and reversely, all those opposite symptoms may reflect malignant tumors. Meanwhile, the preoperative radiographic analyses such as conventional radiography, CT examination and bone scan provide the help for surgeon to identify the nature and origin of tumor. Some scholars thought the biopsy was necessary before surgery (6), and the preoperative judgment is particularly important. However, it is challenging to harvest the pathological tissues of some tumors localizing at the deep surface of the scapula or neighboring spine. For primary rib tumors without pathological diagnosis, Cavanaugh et al (7) considered that the restrictive excisional biopsy should be done first, and the resection range covered the 1 - 2 cm beyond both ends of the lesion. Generally, the intercostal muscle was not resected unless the bone lesions invaded into the surrounding soft tissues. If the pathological diagnosis approved that the first operation was incomplete, then the secondary operation was conducted. In such a way, the resection of chest wall chunks could be avoided for those benign

lesions. However, for malignant rib tumors, a detailed strategy such as the resection range and the method for reconstruction of chest wall should be planned carefully prior to the secondary operation. Qiming Xu et al (8) thought that the resection area should cover the intercostal muscle surrounding the pathology-bearing rib, the deep surface of the parietal pleura, and the superficial muscles, 2-3 cm beyond the both ends, and the muscle was retained as much as possible. Based on these criteria, we resected the benign lesions of rib on more than 30 patients and the integrity of chest wall tissue was maximally retained with no recurrence.

Conventional surgical methods usually bring large trauma to patients with heavily bleeding (9). For those tumors lying in the scapula or deep surface of breast, it is difficult to make the cut straightforward to the tumors, and the structure of chest wall may be heavily damaged. With a 100-year history, thoracoscopy can overcome all these bottlenecks. In recent 20 years, thoracoscopy is widely applied to lung and mediastinal tumor surgery. However, it was rarely reported to be used in the rib tumor surgery. The difficulties of applying thoracoscopy in the resection of rib tumors lie in how to accurately cut rib lesions. Nakagiri proposed to use wire saw while Nennon used rongeur (10, 11), besides, we also tried burr drill, wire saw was the best according to our experiences. Although the relatively bigger rib lesion could be visualized with thoracoscopy, it was still hard to localize the small tumors residing in ribs or protruding into the muscle layer. The soft tissue image obtained from the C-type arm was usually in low resolution, and the contrast agents-enhanced imaging function was not applicable. The body position also limited the scanning of high-ribs, which further narrowed its application.

With the advantages of computer navigation system, the anatomical location and the surgical instruments could be displayed in a real-time and accurate manner. Under its guidance, the resection boundaries could be removed and the surgeon could match preoperative plan with

surgical results during the operation. The preoperative CT imaging covered the bone lesions and the outside soft tissue mass in the entire thorax, so the fusion of the C-type arm or CT-obtained images during operation could either guarantee the safe boundaries or minimize the unnecessary extensive resection in combination with thoracoscopy. Moreover, this method could avoid possible tumor expansion caused by accidently punching the pleural on tumor surface. Breathing might influence the image fusion by interfering the resolution of C-type arm-obtained image, but this worry did not exist in our surgical experiences. Computer navigation technology has been widely used in various medical disciplines, especially in orthopedic, spine, neurosurgery and maxillofacial surgery (12), but it is very rare to be applied in thoracic surgery (13). We reported the resection of rib tumors by minimally invasive thoracoscopy in combination with computer navigation for the first time. Based on our clinical experiences, the combined surgical method is especially feasible for the tiny tumor or some tumors that are unreachable or resided in scapula and deep face of breast.

In conclusion, combination of computer navigation technique and thoracoscopy could assist surgeons to more accurately judge the tumor margin, implement minimal invasive resection, and minimize the trauma of patients. We applied the computer navigation system in the resection of rib tumors for only a short period, and our surgeons are not as skillful as needed, so the operation time was relatively long. However, we believed that the timeline would be dramatically shortened when our surgeons got more practices.

CONFLICTS OF INTEREST

These authors declare that there are no conflicts of interest.

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Table 1: Clinical data of the 4 patients

Gender	Age	Chest pain	Results of X-ray	Results of CT	Bone scanning	Diagnosis	Navigation timeline
Male	38	Yes	Bone destruction	Osteolytic bone destruction with surrounding sclerosis	High uptake	Adverse rib fiber structure (right 3)	60 min
Male	30	Yes	Decreased bone mass and integrity	Low-density areas with surrounding sclerosis	High uptake	Rib fibrous histiocytoma (left 5)	70 min
Female	49	Yes	Bone destruction	Osseous expansion, bone destruction	High uptake	Rib plasmacytoma (left 5)	80 min
Male	49	No	Patchy low-density areas	Local density bone-shadow region	High uptake	Rib reactive hyperplasia (left 8)	70 min