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CLINICAL STUDY

Robot-assisted pulmonary lobectomy

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Abstract: The authors present their first experience and the results of robot-assisted pulmonary lobectomies. The paper reports on the placement of the working channels, auxiliary minithoracotomies, the patient's position, the positions of the four-arm body of the da Vinci robotic system, and particularly the technique of lobectomy. In our institution, 4 robot-assisted lobectomies were performed in two women and two men (aged 45, 52, and 57, 67 years, respectively). The vessels were ligated mechanically with the use of the robot. An auxiliary minithoracotomy of a length of 5 cm was performed in the fifth intercostal area posterolaterally. The lower lobectomy was performed three times left and once right. The surgery was always supplemented with mediastinal lymphadenectomy. No serious complications were observed during the surgery or in the postoperative period. Robot-assisted lobectomy is a safe method of pulmonary resection in the early stages of bronchogenic carcinoma (Ia, Ib); it ensures a faster convalescence of the patient compared with open surgery *(Ref. 14).* Full Text (Free, PDF) *www.bmj.sk.*
Key words: robot, pulmonary lobectomy.

Robot-assisted pulmonary lobectomy is indicated for peripherally situated tumours up to a size of 4 cm, i.e. T1 and smaller T2. Presently, robot-assisted lung lobectomy is performed in two modifications. One of the methods uses auxiliary minithoracotomy already since the start of the surgery, the other (fully endoscopic) performs minithoracotomy at the end of the surgery to remove the resected structure (1). In contradistinction to open and thoracoscopic lobectomies, the preoperative assessment must contain primarily the patient's position, the position of the four-arm body of the robot in relation to the patient's position and to the placement of the individual working channels, as well as the position of the anaesthesia machine, and the console with the monitor for the assistant surgeon and the operating theatre nurse. In this assessment it is necessary to take into account that due to the weight and more difficult manoeuvrability with the robot body, moving any other objects mentioned at the operating theatre is easier. The most frequently used position of the patient is on the side (2, 4, 6) or the anterolateral position (1). The most frequently used position of the robot's body respects the principle that the axis of the middle arm used for the camera is directed at the patient's shoulder and forms an angle of 45 degrees with the axis of the operating table, whereby the patient's head is directed at the robot's body. Further, positions are used where the axis of the robot's middle arm forms angles of 0, or least often 90 degrees with the operating table axis. The placement of the working channels is usually analogous to the thoracoscopic approach. When planning upper lobectomy it is advisable to shift the position of the ports to the front (1). Alternatively, the ports for the lower lobectomy are used in such a way that both the camera and the two arms are placed on one level perpendicular to the course of the intercostal region. The camera is placed in the 5th intercostal area and the arms are over and under its level (10). Usually four working channels are used: a port for the camera, two robotic arms, and an auxiliary working channel for sucking off, feeding and cutting the fibres, and/or loading the stapler. The choice of localisation of the auxiliary minithoracotomy depends on the intention of its utilisation and on the type of lobectomy. In a fully endoscopic lobectomy it is only performed as an extension of the distal working port. In case that the surgery algorithm is initiated by minithoracotomy, the latter may be used instead of the auxiliary working channel. It may serve as a place for the loading of the stapler for the separation of a faded interlobar fissure, and in some cases of a vascular and bronchial stapler. In this case it is then chosen in the fifth intercostal area posterolaterally for the lower lobectomy, and anterolaterally for the upper lobectomy. The positions of minithoracotomy as well as that of the ports in the medium lobectomy are the same as in upper lobectomy. The technique of pulmonary lobectomy is basically the same as in open surgery. However, it is always advisable to start with the preparation and division of the interlobar fissure to ensure better manoeuvrability with the lobe destined for resection. This step may already be performed under full robot assistance (4) or by means of the thoracoscopic technique: preparation of the artery by means of the "gold finger" (2, 9) and separation of the interlobar fissure by the stapler. This is followed by preparation and ligature of the pulmonary vein and by ligature

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of the arteries of the resected lobe. The robotic system enables mechanical ligation of the vessels, i.e. identically to an open-type surgery. However, interruption of the vascular structures by the stapler is possible (10). By means of the stapler the bronchus is interrupted and pulmonary lobectomy is thus completed. After removing the lobe via auxiliary minithoracotomy, the surgical performance is supplemented with mediastinal lymphadenectomy.

Methods

In our institution, 4 robot-assisted lower lobectomies were performed in two women and two men (aged 45, 52, and 57, 67 years, respectively) by means of the da Vinci robotic system. The robotic system makes use of the 3-D image technology and of the high dexterity of the endoscopic instruments – the Endowrist. The indication recommended is NSCLC stage I, diagnosed according to CT (8). The absence of preoperative histological verification means starting the procedure by an atypical resection of the tumour. In this way the surgery was performed once, when the size of the tumour did not reach 1 cm; three times we had to do with histologically proved tumours of a size of 1.5, 2, and 3 cm. We chose the patient's position on the side with a „praying" position of the hands, where the arm and the trunk had to form an angle of 90 degrees. A sharper angle would inhibit free movement of one of the robotic arms. The placement of the robot's body is important in view of the principle that the camera direction, the area under surgery, and the robot's middle arm should be in the same axis. As we require the movement of the camera both in ventral and dorsal direction, we chose the position of the operating table in the same axis with the middle arm of the robot's body. The position of the assistant surgeon was on the side of the auxiliary minithoracotomy or the auxiliary working channel. The position of the operating theatre nurse was at the side opposite to that of the assistance at the patient's feet. At the site opposite to the assistance the endoscopic console with the monitor were placed so that sufficient visibility was ensured even for the theatre nurse. The surgeries were always performed under selective ventilation. A collapse of the operated lung is the basic condition for success of robot-assisted lobectomy. Prior to the surgery, all of patients had an epidural catheter introduced for peri- and postoperative analgesia. The surgeries were performed under an antibiotic screen of ampicillin + sulbactam. An auxiliary minithoracotomy of a length of 5 cm was performed in the fifth intercostal area posterolaterally. For safety reasons we resected a small part of the rib in the first three patients. When placing the working channels, we respected the principle that the distance between the individual ports for the camera and for the robotic arms must be 7 cm at minimum, so that free movement may be ensured for all the arms. The working channels were placed in the 4th intercostal area in the anterior axillary line and the 6th intercostal area in the scapular line for the shoulders, and in the 7th intercostal area in the posterior axillary line for the camera. When placing the camera in the median axillary line there was a contact between the arm and the rib arch or the iliac spine; therefore we immediately abandoned the position. The interlobar fissure was faded in three cases and it was necessary to separate it by means of a stapler. For the preparation we used a cadier and a pair of monopolar scissors with a plastic cover. Here the cadier substituted skilfully the blunt director device employed in an open surgery. The vessels were ligated mechanically using the robot. The centrally positioned linen-thread ligature was always secured with puncture ligature in the same way as in open surgery. We refused to load a vascular stapler owing to an incomparable visual control of the operating surgeon and the assistant surgeon who was to load the stapler (does not see the 3-D image). The bronchus was cut through by the stapler and the lobe was extracted in a plastic packet using auxiliary minithoracotomy. Mediastinal lymphadenectomy was performed at the right side in the compartments containing the lower and hilar mediastinal lymph nodes, and at the left side in the compartments containing the lower mediastinal, hilar, and aortic lymph nodes. In mediastinal lymphadenectomy we used with advantage the clipping of node-supplying vessels.

Results

Lower lobectomy was performed three times at the left and once at the right side. The performance was always supplemented with systematic mediastinal lymphadenectomy, which extends the operative performance by 30 minutes on average. The length of surgical performance was 270 minutes on average (180, 240, 300, 360). The surgery length does not include the preparation of the robot, which takes 15 minutes on average. No serious complications occurred during the surgery or in the postoperative period. A minor complication occurred once; it was a minute air leakage which closed spontaneously after 10 days. The average time of hospitalisation was 7.5 days (6, 6, 8, 10 days). No infectious complications occurred in our cohort. The mortality rate was equal to zero. The advantages of the da Vinci robotic system – 3D image and dexterous endoscopic instruments which enabled a range of motion analogous to human wrist – proved effective in the preparation of hilar structures. In VAS 3–4 the total consumption of the analgesic mixture administered into the epidural line for the first three postoperative days was significantly lower than in open-type surgery. None of the patients received blood transfusion either peri- or postoperatively.

Discussion

The position of the robot's body and of the operating table in lower lobectomy is not apodictically set. Unlike other authors (2, 10) we choose an identical axis of the operating table and the middle arm of the robot for the necessity of the camera movement not only dorsally, but also ventrally. With the position of the table and the robot's middle arm in a 45-degree angle centred to the patient's shoulder, the camera gets, when viewed ventrally, quite markedly out of the required axis of camera, site of surgery, and the robot's middle arm. We prefer to place the camera port into the 7th intercostal area rather in the posterior than the

median axillary line to prevent collision with the patient's rib arch or iliac spine. Resection of a small part of the rib in auxiliary minithoracotomy was used for safety reasons; we were aware of the fact that in doing so we do not fully respect the principles of mini-invasiveness. So far, we have preferred separation of the faded interlobar fissure by means of a stapler for fear that there would be too large air leakage arise if we separate the fissure by electrocoagulation. Another author reports a small percentage of significant air leakages in case of separation of the interlobar fissure in the same way (4). In manual ligature of hilar vessels we used an assurance of the central linen-thread ligature by means of a puncture ligature, which is an antiskid safeguard. Some other authors perform double ligature without punctures, or use a vascular stapler (4, 10). We consider the latter option as unsuitable due to large difficulties connected with the safe loading of the stapler for the assistance that does not have the possibility of 3-D visualisation. Most authors report the duration of the average hospital stay to be 4 to 5 days (1, 4, 8 days). Our average duration of hospitalisation is longer; this was caused by leakage of air which we will try to eliminate in the future by a change of the technique of separation of the faded interlobar fissure (11). The average time of surgery, 270 minutes, is analogous to that reported by other authors (4, 6, 10). The most significant factor affecting the length of the surgery is the surgeon's experience. Another factor is the necessity of wedge resection with cryotome examination in case of histologically unchecked tumours. The surgery time is also influenced by difficult searching for a small tumour located deep inside the parenchyma. Here endosonography may be employed with advantage for its localisation (13). The result of a cryotome examination usually takes 20 to 40 minutes.

A relative disadvantage of robot-assisted lobectomy and robot-assisted surgical operations in general is the absence of a direct haptic perception or of an instrument-mediated tactile perception (VATS) (4). This is only a relative disadvantage, because the loss of feeling in the knotting and tightening of the ligatures of hilar vessels is compensated by a perfect 3-D visualisation. We have become unexpectedly quickly accustomed to the substitution of the more perfect visual perception for the tactile perception (12, 14).

Conclusion

Robot-assisted lobectomy is a safe method of pulmonary resection in the early stages of bronchogenic carcinomas (Ia, Ib), which ensures a faster convalescence of the patient compared to an open surgery. The choice of placement of the working channels depends particularly on the location of the pathological focus, and it is highly important for the free movement of robotic arms and the camera, which ensures good preparation. The correct choice of placement of auxiliary thoracotomy plays a role not only owing to the assistance in loading a stapler when separating the interlobar fissure, but especially owing to the possibility of fast conversion in the case of an emergency.

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