Surgical chest complications after liver transplantation

Apostolos C Agrafiotis, Konstantina-Eleni Karakasi, Mathilde Poras, Stavros Neiros, Stella Vasileiadou, Georgios Katsanos

Abstract

Liver transplantation is a major abdominal operation and the intimate anatomic relation of the liver with the right hemidiaphragm predisposes the patient to various manifestations in the chest cavity. Furthermore, chronic liver disease affects pulmonary function before and after liver transplantation resulting in a considerable percentage of patients presenting with morbidity related to chest complications. This review aims to identify the potential chest complications of surgical interest during or after liver transplantation. Complications of surgical interest are defined as those conditions that necessitate an invasive procedure (such as thoracocentesis or a chest tube placement) in the chest or a surgical intervention performed by a thoracic surgeon. These complications will be classified as perioperative and postoperative; the latter will be categorized as early and late. Although thoracocentesis or a chest tube placement is usually sufficient when invasive measures are deemed necessary, in some patients, thoracic surgical interventions are warranted. A high index of suspicion is needed to recognize and treat these conditions promptly. A close collaboration between abdominal surgeons, intensive care unit physicians and thoracic surgeons is of paramount importance.

Key Words: Surgical chest complications; Liver transplantation; Chest related morbidity; Multidisciplinary treatment; Surgery

©The Author(s) 2022. Published by Baishideng Publishing Group Inc. All rights reserved.
Core Tip: Chest complications during and after liver transplantation significantly affects the surgical and hospitalization outcomes. This minireview focuses on surgical chest complications for transplant patients and categorizes them by time of appearance. This paper may be a helpful guide and tool for medical students, members of the transplantation team and all the collaborative specialties to recognize early chest complications and plan the appropriate treatment.

Citation: Agrafiotis AC, Karakasi KE, Poras M, Neiros S, Vasilciadou S, Katsanos G. Surgical chest complications after liver transplantation. World J Transplant 2022; 12(11): 359-364
URL: https://www.wjgnet.com/2220-3230/full/v12/i11/359.htm
DOI: https://dx.doi.org/10.5500/wjt.v12.i11.359

INTRODUCTION
The diaphragm is the boundary between the thoracic and abdominal cavities. Yet, it is common in everyday clinical practice to observe pathologies that originate in one cavity impacting the other[1]. Liver transplantation is a major abdominal operation and the proximity of the operating field with the right hemidiaphragm predisposes it to various manifestations in the chest cavity. Furthermore, chronic liver disease affects pulmonary function before and after liver transplantation resulting in a considerable percentage of patients presenting with morbidity related to chest complications. Age, model for end stage liver disease (MELD) score, preexisting lung disorders and perioperative events, particularly transfusion, contribute to these complications[2]. Indeed, pulmonary complications constitute a significant problem after liver transplantation[3-5]. In one retrospective study enrolling 135 patients, the first postoperative chest roentgenogram was within normal limits in less than half of the cases[6]. In another cohort of adult-to-adult living donor liver transplantation, chest complications were observed in 19.8% of recipients[7]. In the retrospective study by Panfili et al[8], pulmonary complications were frequently revealed on imaging during the first postoperative week.

This review aims to identify the potential chest complications of surgical interest during or after liver transplantation. Complications of surgical interest are defined as those conditions that necessitate an invasive procedure (such as thoracocentesis or a chest tube placement) in the chest or a surgical intervention performed by a thoracic surgeon. These complications will be classified as perioperative and postoperative; the latter will be categorized as early and late.

PERIOPERATIVE COMPlications
Intraoperative pneumothorax is a well described complication of surgery with liver transplantation not being an exception and should be promptly recognized and treated as it can result in life-threatening tension pneumothorax. Pneumothorax can occur because of a bleb rupture, a tracheobronchial trauma during orotracheal intubation, an accidental lung puncture during central venous catheter placement or diaphragm perforation during dissection and barotrauma. Bozbas et al[9] described another mechanism during liver transplantation. After the extraction of a voluminous native liver, the rapid expansion of the right lower lobe resulted in a massive air leak, probably due to the development of important shear forces that damaged the pulmonary parenchyma. The insertion of a chest tube is the first therapeutic measure, while persistent air leaks or tracheobronchial lacerations should be treated accordingly.

POSTOPERATIVE COMPlications
Early postoperative complications
The most typical early postoperative complication is pleural effusion with an estimated incidence of 32%-47%[9-11]. It occurs more frequently on the right side, with left-sided occurrence being rare. Its pathogenesis is multifactorial. Ritschl et al[12] identified the following mechanisms responsible for the occurrence of pleural effusion: (1) Low serum albumin levels and postoperative hypoproteinemia; (2) High rates of intraoperative blood and fluid transfusions; and (3) Local mechanisms at the right side of the diaphragm. More specifically, the diaphragmatic defects allow fluid migration towards the chest cavity. Moreover, right hemidiaphragmatic paralysis caused by perioperative right phrenic nerve injury results in the right lower lobe atelectasis, favoring the development of pleural effusion.

There is no consensus concerning indications for chest tube placement and the choice of treatment modality depends mostly on clinical experience and individual appreciation. Similarly, there is no recommendation concerning the type and size of the chest tube. Chest tube placement is necessary for
22%−52% of liver recipients. In a large retrospective study analyzing 597 liver recipients, 12 patients with effusion were treated by a chest tube and had a higher MELD score. Other significant risk factors are recipient body mass index (BMI), hospitalization status before liver transplantation [home, hospital, intensive care unit (ICU)], number of intraoperative red blood cell transfusions and donor BMI[8]. There are emerging recommendations advocating for preventive right chest tube placement in the early postoperative period since a decrease in infectious pulmonary complications and ICU stay has been observed[12]. However, the potential complications of invasive percutaneous pleural procedures (thoracentesis and chest tube placement) should also be considered. The more frequent complications are pneumothorax due to accidental lung puncture and hemothorax due to coagulopathy or technical pitfalls causing minor (pleural) or significant (vacular injury most of the time involving an intercostal artery) hemorrhage. In a large retrospective multicentric study, the incidence of hemothorax was 0.42%, and it was more frequent among patients who underwent thoracocentesis[13]. Nearly half of these patients underwent thoracic surgery (thoracotomy or thoracoscopy). This condition was associated with a high (50%) mortality rate. Postoperative hemothorax can also occur after central venous catheter introduction, especially in patients with coagulopathy[13]. Diaphragmatic lacerations or resection during liver transplantation can also result in postoperative hemothorax. The mispositioning of the chest tube (in the subcutaneous tissues or a subdiaphragmatic location) must also be cited. Another complication is re-expansion pulmonary edema, which occurs during the rapid evacuation of massive pleural effusions[14].

Bacterial pneumonia is a common postoperative complication in liver recipients. In the retrospective study of Ma et al[15], one-third of patients enrolled developed bacterial pneumonia[15]. This group of patients had an extended hospital stay and more frequent pleural effusions than patients without pneumonia. Without prompt treatment, a parapneumonic pleural effusion can evolve into a pleural empyema, a significant source of morbimortality[16].

Mid-term and chronic postoperative complications

Liver recipients are prone to opportunistic infections because of immunosuppression. Some conditions may affect the lung and cause lung necrosis and cavitation[17]. Consequently, air leaks may result in pneumothorax, pneumomediastinum and subcutaneous emphysema[18,19]. A common pathogen is *Pneumocystis jirovecii*, and treatment is no different than in the general population; watchful waiting, chest tube placement or exploratory thoracoscopy. Pneumocystis pneumonia is a relatively late complication after liver transplantation; however, it can occur at an earlier setting (within 1 to 3 wk postoperatively). Its incidence is very low (inferior to 1% during the 1st year) in patients receiving prophylaxis, while it is estimated to be between 3% and 11% in the absence of prevention[19,20].

Invasive aspergillosis is the second most common fungal infection after liver transplantation and is associated with high mortality rates[21,22]. A high clinical suspicion is warranted, especially in the early postoperative period. A computed tomography scan is beneficial in identifying the characteristic lesions caused by invasive aspergillosis. Antifungal drugs are the mainstay of treatment, but lung resection can be curative in selected cases as in the case reported by Abe et al[23].

The diaphragm itself can be injured during liver transplantation and result in substantial morbidity, as in the case reported by Rosat et al[24]. Their patient experienced a left diaphragmatic herniation 5 years after orthotopic liver transplantation. This complication is more common in pediatric patients but rare in adult patients. A traumatic dissection and the excessive use of cautery during liver transplantation are factors responsible for the devitalization of the diaphragmatic muscle. The immunosuppression hinders the healing process. The negative intrathoracic pressure combined with the positive intraabdominal pressure results in the defect’s enlargement and the migration of the abdominal viscera into the thorax. The clinical spectrum may vary from totally asymptomatic patients or the presence of non-specific digestive symptomatology to life-threatening visceral strangulation. Once a diaphragmatic hernia is detected, elective repair is warranted, and the abdominal approach is privileged over the thoracic, although there is still debate concerning optimal surgical access.

Chronic pleural effusions constitute a significant source of morbidity among liver recipients. A thick visceral fibrous peel develops if a pleural effusion is untreated, resulting in a trapped lung and restrictive respiratory syndrome. Cuk et al[25] provides an overview of this entity. In their retrospective study, the incidence of the trapped lung in patients with persistent pleural effusion was 21.4%. These patients present increased mortality, extended hospital stay and more surgical interventions in the chest. In this cohort, nearly all pleural effusions were exudates, which support the hypothesis that a chronic inflammatory process occurs in the pleural cavity resulting in the migration of fibroblasts and the development of the pleural peel. Parapneumonic pleural effusions, especially pleural empyema, are a major cause of trapped lung occurrence. Intraabdominal sepsis is a predisposing factor for developing pleural empyema[1]. A frequent pitfall while treating these patients is the false diagnosis of pneumothorax after a thoracentesis for pleural effusion. It is instead a suboptimal lung expansion rather than a true pneumothorax. Sometimes the thickened visceral pleura is visualized in the chest roentgenogram and the correct diagnosis can be established, avoiding thus unnecessary additional pleural interventions such as chest tube placement and elevated suction levels that can result in a lung tear. Shirali et al[16] analyzed the outcomes of 33 liver recipients with pleural space complications who necessitated a thoracic surgical intervention due to chronic pleural effusion and empyema. The most common thoracic
Agrafiotis AC et al. Surgical chest complications/liver transplantation

Table 1 List of complications and prevention measures

| Timing of complication | Type of complication                      | Prevention measures                                                                 |
|------------------------|-------------------------------------------|-------------------------------------------------------------------------------------|
| Intraoperative         | Pneumothorax                              | High level of suspicion                                                             |
|                        |                                           | Cautious OT intubation                                                             |
|                        |                                           | CVC placement under echography guidance                                           |
|                        |                                           | Low airway pressures during mechanic ventilation                                  |
|                        |                                           | Closure of diaphragmatic defects encountered during LTx                             |
| Early postoperative    | Pleural effusion                          | Correction of hypoproteinemia                                                      |
|                        |                                           | Limited perioperative blood transfusions                                           |
|                        |                                           | Proper surgical technique                                                          |
|                        |                                           | Preventive chest tube placement                                                   |
|                        | Pneumothorax                              | Echographic guidance for percutaneous pleural procedures                            |
|                        | Hemorthorax                               | Correction of coagulopathy                                                        |
|                        |                                           | Echographic guidance for percutaneous pleural procedures                            |
|                        |                                           | Proper surgical technique during LTx                                               |
|                        | Atelectasis                               | Pain management                                                                   |
|                        |                                           | Chest physiotherapy                                                               |
|                        |                                           | Drainage of pleural effusions                                                    |
|                        | Chest tube misplacement                   | Proper surgical technique                                                         |
|                        | Re-expansion pulmonary edema              | Staged evacuation of massive pleural effusions                                    |
|                        | Bacterial pneumonia                       | Chest physiotherapy                                                               |
|                        |                                           | Early extubation and weaning from mechanical ventilation                          |
|                        | Pleural empyema                           | Prevention and treatment of atelectasis                                           |
| Mid-term and chronic   | Opportunistic infections causing lung necrosis and cavitation | Drainage of parapneumonic pleural effusions                                     |
|                        | Invasive aspergillosis                    | Proper prophylaxis                                                                |
|                        |                                           | High clinical suspicion                                                           |
|                        | Diaphragmatic herniation                  | Prompt imaging (CT scan)                                                          |
|                        |                                           | Proper surgical technique during LTx                                               |
|                        | Trapped lung                              | Prompt treatment of pleural effusion before chronicity                            |
|                        |                                           | Radical treatment of pleural empyema                                              |

CT: Computed tomography; CVC: Central venous catheter; LTx: Liver transplantation; OT: Orotracheal.

Operations were decortication and empyema evacuation. The 30-d morbidity was 69.7%. The authors concluded that developing pleural space complications requiring surgery in orthotopic liver transplant recipients suggest a poor prognosis.

CONCLUSION

Surgical chest complications following liver transplantation are prevalent and constitute a significant source of morbidity and mortality (Table 1). Most of these complications in liver recipients do not differ from the formal population, whilst others are specific to the transplanted patients primarily because of the immunosuppression. A thoracocentesis or a chest tube placement is usually sufficient when invasive measures are deemed necessary. Nevertheless, in some patients, thoracic surgical interventions are warranted. A high index of suspicion is necessary to recognize and treat these conditions promptly. A close collaboration between abdominal surgeons, ICU physicians and thoracic surgeons is of paramount importance.
FOOTNOTES

Author contributions: Agrafiotis AC, Poras M and Katsanos G were involved in the conception and design; Karakasi KE and Neiros S were administrative support; Poras M, Karakasi KE and Neiros S contributed to the provision of the study material; Poras M, Karakasi KE and Neiros S were involved in the collection and assembly of data; Agrafiotis AC, Vasileiadou S and Katsanos G were involved in the data analysis and interpretation; and all authors wrote the manuscript and approved the final manuscript.

Conflict-of-interest statement: All the authors report having no relevant conflicts of interest for this article.

Open-Access: This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: https://creativecommons.org/Licenses/by-nc/4.0/

Country/Territory of origin: Greece

ORCID number: Apostolos C Agrafiotis 0000-0002-7525-208; Konstantina-Eleni Karakasi 0000-0003-2448-556X; Mathilde Poras 0000-0003-2524-2930; Stavros Neiros 0000-0002-5110-1122; Stella Vasileiadou 0000-0001-9143-6085; Georgios Katsanos 0000-0002-3845-8175.

S-Editor: Wang JJ
L-Editor: Filipodia
P-Editor: Wang JJ

REFERENCES

1 Gounard C, Fuks D, Cauchy F, Belghiti J, Pugam-Burtz C, Castier Y, Soubrane O. Pleural Empyema Following Liver Resection: A Rare But Serious Complication. World J Surg 2016; 40: 2999-3008 [PMID: 27464918 DOI: 10.1007/s00268-016-3657-0]
2 Lui JK, Spaho L, Holzwanger E, Bui R, Daly JS, Bozorgzadeh A, Kopec SE. Intensive Care of Pulmonary Complications Following Liver Transplantation. J Intensive Care Med 2018; 33: 595-608 [PMID: 29552956 DOI: 10.1177/0885066618757410]
3 Shieh WB, Chen CL, Wang KL. Respiratory changes and pulmonary complications following orthotopic liver transplantation. Transplant Proc 1992; 24: 1486-1488 [PMID: 1496629]
4 Hong SK, Hwang S, Lee SG, Lee LS, Ahn CS, Kim KH, Moon DB, Ha TY. Pulmonary complications following adult liver transplantation. Transplant Proc 2006; 38: 2979-2981 [PMID: 17112879 DOI: 10.1016/j.transproceed.2006.08.090]
5 Feltracco P, Carollo C, Barbieri S, Pettenazzo T, Ori C. Early respiratory complications after liver transplantation. World J Gastroenterol 2013; 19: 9271-9281 [PMID: 24409054 DOI: 10.3748/wjg.v19.i48.9271]
6 Doğrul MI, Akçay S, Savas Bozbaş Ş, Er Dedektarınçılğın B, Öner Eyüboğlu F, Moray G, Haberal M. Early pulmonary complications of liver transplant. Exp Clin Transplant 2014; 12 Suppl 1: 153-155 [PMID: 24635815]
7 Gad EH, Alshebaei A, Lotfy M, Eltabbakh M, Sheriff AA. Complications and mortality after adult to adult living donor liver transplantation: A retrospective cohort study. Ann Med Surg (Lond) 2015; 4: 162-171 [PMID: 26005570 DOI: 10.1016/j.amsu.2015.04.021]
8 Panfili E, Nicolini D, Polverini V, Agostini A, Vivarelli M, Giovagnoni A. Importance of radiological detection of early pulmonary acute complications of liver transplantation: analysis of 259 cases. Radiol Med 2015; 120: 413-420 [PMID: 25421263 DOI: 10.1007/s11547-014-0472-2]
9 Bozbas SS, Eyüboğlu FO, Ozturk Ergur F, Gullu Arslan N, Sevmsis N, Karakayali H, Haberal M. Pulmonary complications and mortality after liver transplant. Exp Clin Transplant 2008; 6: 264-270 [PMID: 19338487]
10 Pirat A, Ozgur S, Torgay A, Candan S, Zeyneloglu P, Arslan G. Risk factors for postoperative respiratory complications in adult liver transplant recipients. Transplant Proc 2004; 36: 218-220 [PMID: 15013351 DOI: 10.1016/transproceed.2003.11.026]
11 Lin YH, Cai ZS, Jiang Y, Lu LZ, Zhang XJ, Cai QC. Perioperative risk factors for pulmonary complications after liver transplantation. J Int Med Res 2010; 38: 1845-1855 [PMID: 21309501 DOI: 10.1177/03000605103800532]
12 Ritschel P, Wiering L, Spoonholz F, Brandt A, Aigner F, Biebl M, Schmelzle M, Euirich D, Sauer I, Kotsch K, Pratschke J, Øllinger R. Preemptive Chest Tube in Liver Transplantation – An Unconventional Way to Reduce Morbidity. Am J Transplant 2017; 17
13 Panaro F, Al Taweel B, Leon P, Ghinolfi D, Testa G, Kalisvaart M, Muişes P, Romagnoli R, Lesurtel M, Cassese G, Trüani S, Addeo P, Sainz-Barrica M, Baccarani U, De Simone P, Belafia F, Herrero A, Navarro F. Morbidity and mortality of iatrogenic hematomas occurring in a cohort of liver transplantation recipients: a multicenter observational study. Updates Surg 2021; 73: 1727-1734 [PMID: 34216370 DOI: 10.1007/s11304-021-01099-0]
14 Kara S, Sen N, Akçay S, Moray S, Kus M, Haberal M. Liver Transplant and Reexpansion Pulmonary Edema: A Case Report. Exp Clin Transplant 2018; 16 Suppl 1: 154-157 [PMID: 29528016 DOI: 10.6002/ect.TOND-TDTD2017.P43]
15 Ma YK, Yan LN, Li B, Lu SC, Huang AH, Wen TF, Zeng Y, Cheng NS. Diagnosis and treatment of bacterial pneumonia in liver transplantation recipients: report of 33 cases. Chin Med J (Engl) 2005; 118: 1879-1885 [PMID: 16313842]
16 Shirali AS, Grotts J, Elashoff D, Bajaktaresvic I, Melamed KH, Van Hassel J, Cameron RB, Lee JM, Yanagawa J.
Predictors of Outcomes After Thoracic Surgery in Orthotopic Liver Transplant Recipients With Pleural Disease. *Semin Thorac Cardiovasc Surg* 2019; 31: 604-611 [PMID: 30731193 DOI: 10.1053/j.semtcvs.2019.02.003]

17 Xia Y, Zhou H, Zhu F, Zhang W, Wu C, Lu L. Diagnosis and treatment of pulmonary cavity after liver transplantation. *Ann Transl Med* 2017; 5: 301 [PMID: 28856141 DOI: 10.21037/atm.2017.05.14]

18 Okoh S, Gopal KV. Pneumothorax in Pneumocystis jirovecii Pneumonia: A case report, review of clinical characteristics and management. *American J Case Rep* 2008; 9: 120-124

19 She WH, Chok KSH, Li IWS, Ma KW, Sin SL, Dai WC, Fung JYY, Lo CM. Pneumocystis jirovecii-related spontaneous pneumothorax, pneumomediastinum and subcutaneous emphysema in a liver transplant recipient: a case report. *BMC Infect Dis* 2019; 19: 66 [PMID: 30658592 DOI: 10.1186/s12879-019-3723-y]

20 Kostakis ID, Sotiropoulos GC, Kouraklis G. Pneumocystis jirovecii pneumonia in liver transplant recipients: a systematic review. *Transplant Proc* 2014; 46: 3206-3208 [PMID: 25420860 DOI: 10.1016/j.transproceed.2014.09.156]

21 Tomiyama T, Motomura T, Iseda N, Morinaga A, Shimagaki T, Kurihara T, Wang H, Toshima T, Nagao Y, Itoh S, Harada N, Yoshizumi T, Mori M. Acute death caused by invasive aspergillosis after living-donor liver transplantation despite good graft function: a case report. *Surg Case Rep* 2021; 7: 118 [PMID: 33978845 DOI: 10.1186/s40792-021-01203-w]

22 Park JW, Kim WB, Han JH, Choi SB, Yeon JE, Byun KS, Choi SY. Invasive pulmonary aspergillosis after living donor liver transplantation should be eradicated or not? *Transplant Proc* 2011; 43: 2428-2430 [PMID: 21839284 DOI: 10.1016/j.transproceed.2011.05.034]

23 Abe K, Shinoda M, Uno S, Obara H, Kitago M, Abe Y, Hishida T, Yagi H, Hasegawa Y, Kitagawa Y. Invasive pulmonary aspergillosis after liver transplantation: lessons from successfully treated cases and review of the literature. *Surg Today* 2021; 51: 1361-1370 [PMID: 33738584 DOI: 10.1007/s00595-021-02263-z]

24 Rosat A, Alonso A, Padilla J, Sanz P, Varona MA, Mendiñ, Moneva E, Barrera M. Left Diaphragmatic Herniation following Orthotopic Liver Transplantation in an Adult. *Case Rep Surg* 2015; 2015: 836142 [PMID: 26064764 DOI: 10.1155/2015/836142]

25 Cuk N, Melamed KH, Vangala S, Salah R, Miller WD, Swanson S, Dai D, Antongiorgi Z, Wang T, Agopian VG, Dinocia J, Farmer DG, Yanagawa J, Kaldas FM, Barjaktarevic I. Postoperative Trapped Lung After Orthotopic Liver Transplantation is a Predictor of Increased Mortality. *Transpl Int* 2022; 35: 10387 [PMID: 35592450 DOI: 10.3389/fitr.2022.10387]
