STAGED WOUND MANAGEMENT WITH MESH CLOSURE IN PATIENT WITH INTRA-ABDOMINAL HYPERTENSION AFTER LIVER TRANSPLANTATION: EVALUATION AND CRITICAL CARE

Chia-En Hsieh¹, Hui-Chuan Lin², Kuo-Hua Lin³, Chia-Cheng Lin³, Ping-Yi Lin⁴, Su-Han Wang¹, Yao-Li Chen⁵

Abstract

This paper aims to discuss the application of synthetic mesh in liver transplantation complicated by intra-abdominal hypertension (IAH) or abdominal compartment syndrome (ACS) with decreasing intra-abdominal pressure and postoperative nursing. Factors for liver transplantation complicated by IAH included: 1. recurrent intra-abdominal bleeding due to the severe postoperative coagulation disorder, 2. postreperfusion hepatic edema, especially marginal grafts, 3. donor/recipient graft size mismatch, 4. bowel edema after portal vein clamping during transplantation. According to patient’s of Changhua Christian Hospital, from 2002 to 2010, there were 65 liver transplantations that had been completed; nine cases of IAH/ACS were observed. Among them, four patients received wound closure with a mesh. Currently, the hospital uses a synthetic mesh as an intervention at the time of wound closure when the central venous pressure increases more than 5mmHg. The timing for the synthetic mesh removal depends on the recovery condition (waist circumference and decreased intra-abdominal pressure) of hepatic and bowel edema after the transplantation; also, in order to prevent infections, the exploratory laparotomy procedure is performed 7-14 days after the surgery to remove the mesh. This paper records the keypoints for physiological evaluation and nursing to assist early detection and prevention of IAH/CAS symptoms, complications and infections. Patients received abdominal catheter drainage or emergency surgery to prevent further organ failure or severe infections. The techniques and experiences are shared for transplant surgeon and intensive care unit (ICU) medical team’s nursing reference.

Key Words: Liver transplantation, Intra-abdominal hypertension, Abdominal compartment syndrome, Mesh

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Introduction

Intra-abdominal hypertension (IAH) and abdominal compartment syndrome (ACS) are frequently observed symptoms in ICU. Compartment syndromes occur inside a closed space within the body. When the pressure within the space rises, normal tissues and functions will be damaged. The normal IAP is around 5-7mmHg; after exploratory laparotomy, the postoperative IAP may increase to 15mmHg in severe patients and lead to major organ dysfunction. Patients with IAH 25mmHg usually appear with the clinical symptom of organ failure, which is a very severe fatal condition. The mortality rate is from 38-71%. Major causes of acute IAH/ASC include retroperitoneal hemorrhage, pelvic bleeding, visceral edema, and postresuscitation states. Other causes include pancreatitis, intraabdominal hemorrhage, laparoscopy with pneumoperitoneum, bowel distension, ileus, venous mesenterial obstruction, intestinal obstruction, ruptured abdominal aortic aneurysm, tense ascites, peritonitis, neoplasms, septic shock, pregnancy, and liver transplantation (LT).

Factors causing LT complicated by IAH/ACS include: 1. intra-abdominal bleeding, such as severe postoperative coagulation disorder, 2. postreperfusion hepatic edema, especially marginal grafts, 3. donor/recipient graft size mismatch. 4. bowel edema after portal vein clamping during LT. Biancofiore et al stated that the incidence rate of raised IAP (> 25mmHg) during LT was 31%. When ACS occurs during LT, the patient must receive decompressive laparotomy immediately to control the elevation of IAP > 25mmHg. This study provides a solution for IAH following LT by the method of wound closure with synthetic mesh.

Methods

Patient

According to the organ donation statistics of Changhua Christian Hospital, from October 2002 to December 2013, there were 183 adult recipients that had been completed. The recipients comprised 48 cases orthotopic liver transplantation (OLT) and 135 cases living donor of liver transplantation (LDLT). Deceased donor LT was a piggyback and LDLT was a hepatic vein to inferior vena cava technique used for implantation.

Penicillins or cephalosporins were used as the third line prophylactic antibiotics from the day of LT. Steroid therapy was After matching the hepatic portal vein, methylprednisolon 500mg was administered before graft reperfusion. The standard immunosuppression protocol comprised tacrolimus (Prograf), mycophenolate mofetil (Cellcept) and a low dose steroid. Prednisone was withdrawn in most patient by 6 months posttransplantation.

After LT, regular physiological and hemodynamic monitoring system, hourly abdominal catheter and urine volume monitoring and routine waist circumference and body weight measurement were performed. Test items included hematology, serum biochemistry, blood gas analysis and immunosuppressant concentration measurement (keeping tacrolimus tough level between 5-15 ng/mL). Examination items included abdominal doppler ultrasonography, which was performed once daily for the first three postoperative days and then once every two days. One week after the operation, follow-up examination would be applied only when abnormal hepatic index was observed. If the postoperative waist circumference kept increasing, IAP would be monitored. Records from the monitor were noted once every 2-4 hours.

Surgery timing and procedure

In the study, IAP was detected in nine patients after LT during ICU stay which exceeded 25-30mmHg. Bed-side abdominal sonography were used to evaluate the cause of IAP. These drainage was clogged by blood clot, the abdomen drainage with pigtail was placed. But the patient happen abdominal hematoma or inter-abdominal bleeding, this patient would be performed to re-
move hematoma for emergency exploratory laparotomy.

Secondly, at the time of abdominal wound closure after the surgical procedure, intrathoracic pressure and central venous pressure were raised rapidly (increasing 5mmHg) and interrupted the wound closure procedure. In this case, at the time of abdominal wound closure after the surgical procedure, a synthetic mesh was placed on the peritoneum (Figure 1, 2); the mesh was stitched and fixed along the upper abdominal wall without closing the abdominal fascia. It mainly reduced the pressure on organs and vessels after the abdominal fascial closure and prevented IAH events and organ failure complications. However, at the time of catheter placement, a catheter should be placed above the mesh to drain the fluid or blood away from the abdominal cavity; the wound was prevented from the soaked and wetted condition to avoid infections. In this paper, etiologies of IAH/ACS for nine patients at the time of liver transplantation will be discussed.

Results

From October 2002 to December 2011, there were 113 adult recipients that had been completed in Changhus Christian Hospital among them, nine cases experienced IAH/ACS events (Table 1 & 2). The ninth patient suffered from Hepatitis B complicated by acute liver failure; the other eight patients suffered from end-stage cirrhosis. Those nine patients received liver transplantation.

During the postoperative ICU care period, six patients experienced IAH/ACS events; they were patient 1, 2, 3, 4, 5 and 7. Only patient 2 suffered from the drainage problem, and was treated by replacing the abdominal catheter to improve the condition of IAH/ASC; the other five patients were treated by emergency exploratory laparotomy to remove blood clots. Then, they were returned to ICU care. However, after the IAH/ASC event, patient 5 experienced oliguria and anuria (acute renal failure). Facing ACS event, while the blood pressure of the patient was stable, emergency exploratory laparotomy was performed to remove blood clots. During the surgery, the central venous pressure was high and the uretic used did not improve the urine volume effectively; anuria still existed persistently and the patient could not dehydrate and lower the CVP level. After the ACS event, the condition of hepatic and bowel edema worsened; therefore, a synthetic mesh was used to close the wound to avoid further increased IAP and excessive CVP, which may affect cardio-
When the patient returned to ICU, continuous renal replacement therapy (CRRT) was performed to dehydrate the patient and maintain cardiac, pulmonary and kidney functions. A week later, the urine volume of the patient increased gradually and the kidney function returned slowly.

For patient 6, 8 and 9, due to postreperfusion hepatic edema, especially marginal grafts; donor/recipient graft size mismatch; and bowel edema after portal vein clamping, at the time of abdominal wound closure after liver transplantation, the intrathoracic pressure and the central venous pressure rapidly exceeded more than 5mmHg. The condition prevented further wound closure procedures and so a synthetic mesh was used to close the abdominal wound. When the wound was closed, the central venous pressure became 12-15mmHg.

Thus, there were four patients that used a synthetic mesh to close the abdominal wound; 17 days after the surgery, patient 5 presented with high fever and infection symptoms. It was suspected to be an intraabdominal infection, and an exploratory laparatomy procedure was performed immediately to remove the mesh in the abdominal cavity. When the infection condition improved, the patient was discharged from the hospital successfully. When the waist circumference constantly decreased with the stable IAP, the other 3 patients (patient 6, 8, 9) removed the mesh from the abdominal cavity on postoperative Day 7, 9, 14, respectively, by surgery to prevent infections.

Among those nine patients, two died. Four years after LT, patient 4 suffered from the severe traumatic brain injury complicated by cerebral hemorrhage and edema; the patient died in the end. patient 9 suffered from acute onset Hepatitis B, leading to acute liver failure complicated by hepatic encephalopathy; the patient was in a severe coma with epilepsy symptoms. The brain computed tomography image showed cerebral edema without intracerebral hemorrhage and uncus hernation. Emergency LDLT was performed and the patient was still in the conditions of severe coma, mydriasis, and diabetes insipidus after the transplantation. 55th days of LT, the patient died from central nervous system failure, due to severe brain swelling.

Table 1. Basic Information

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MELD score: The model for end-stage liver disease scoring. OLT: Orthotopic liver transplantation; LDLT: Living donor of liver transplantation; IVC: Inferior vena cava; PV: Portal vein
<table>
<thead>
<tr>
<th>Patient</th>
<th>IAH/ACS causes</th>
<th>Events</th>
</tr>
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</table>
| 1       | 1. Intra-abdominal bleeding due to severe postoperative coagulation disorder  
2. Postreperfusion hepatic edema, especially marginal grafts  
3. Donor/recipient graft size mismatch | 1. Ascites : 9400ml  
2. Graft : 1545gm  
3. Native liver weight: 700 gm  
4. Blood loss: 21000ml  
5. Marginal graft: Mild fatty liver |
| 2       | 1. Intra-abdominal bleeding due to severe postoperative coagulation disorder  
2. Postreperfusion hepatic edema, especially marginal grafts | 1. Ascites : 1000ml  
2. Graft : 1057gm  
3. Native liver weight: 867 gm  
4. Blood loss: 4145ml  
5. Marginal graft: High dose inotropic requirement, High serum Na |
| 3       | 1. Intra-abdominal bleeding due to severe postoperative coagulation disorder  
2. Postreperfusion hepatic edema, especially marginal grafts | 1. Ascites : 150ml  
2. Graft : 1240gm  
3. Native liver weight: 777 gm  
4. Blood loss: 7350ml  
5. Marginal graft: High dose inotropic requirement, Donor with positive virology: anti-HCV (+) |
| 4       | 1. Intra-abdominal bleeding due to severe postoperative coagulation disorder  
2. Postreperfusion hepatic edema, especially marginal grafts | 1. Ascites : 600ml  
2. Graft : 1420gm  
3. Native liver weight: 1054 gm  
4. Blood loss: 8100ml  
5. Marginal graft: Severe fatty liver |
| 5       | 1. Intra-abdominal bleeding due to severe postoperative coagulation disorder  
2. Postreperfusion hepatic edema, especially marginal grafts  
3. Donor/recipient graft size mismatch | 1. Ascites : few  
2. Graft : 1780gm  
3. Native liver weight: 750 gm  
4. Blood loss: 12550ml  
5. Marginal graft: Mild fatty liver |
| 6       | 1. Postreperfusion hepatic edema, especially marginal grafts  
2. Donor/recipient graft size mismatch | 1. Ascites : 2050 ml  
2. Graft : 1940gm  
3. Native liver weight: 936 gm  
4. Blood loss: 9800ml  
5. Marginal graft: Mild fatty liver |
| 7       | 1. Intra-abdominal bleeding due to severe postoperative coagulation disorder | 1. Ascites : few  
2. Graft : 610gm  
3. Native liver weight: 1380 gm  
4. Blood loss: 23000ml |
| 8       | 1. Donor/recipient graft size mismatch | 1. Ascites : few  
2. Graft : 1920gm (resection 380gm, total 2300gm)  
3. Native liver weight: 920 gm  
4. Blood loss: 4500ml |
| 9       | 1. Bowel edema after portal vein clamping | 1. Ascites : few  
2. Graft : 752gm  
3. Native liver weight: 658 gm  
4. Blood loss: 2900 ml |
Discussion

Factors causing 9 patients of LT complicated by IAH/ACS at Changhua Christian Hospital were: (1) intra-abdominal bleeding due to the severe or postoperative coagulation disorder (Patient 1, 2, 3, 4, 5, 7), (2) postreperfusion hepatic edema, especially marginal grafts, (Patient No 1, 2, 3, 4, 5, 6), (3) donor/recipient graft size mismatch (patient 1, 5, 6, 8), and (4) bowel edema after portal vein clamping during transplantation (patient 4). Intra-abdominal bleeding due to the severe or postoperative coagulation disorder was the frequently observed cause after transplantation; approximately 10% patients required another surgical procedure within the first 24-48 hours due to recurrent bleeding.\textsuperscript{7} The most important risk factor for early bleeding was the preoperative condition of severe coagulation disorder and reduced platelet count in the patient. Especially when liver transplantation had just been performed, in the early stage, sufficient coagulation factors could not be synthesized.\textsuperscript{8,9} Six patients experienced recurrent bleeding within 24 hours after the transplantation due to the preoperative condition of severe coagulation disorder and reduced platelet count; the average bleeding volume during the surgery was above 12690ml. In addition, since marginal donor graft was used, temporary postoperative primary nonfunction also occurred and resulted in coagulation disorder. However, the bleeding volume for patient 2 was less, the complication of IAH/ACS was due to improper drainage; when the abdominal catheter was replaced, the condition was improved with decreased intra-abdominal pressure.

Postreperfusion hepatic edema, especially marginal grafts, was the second factor for IAH/ACS events. Marginal grafts included steatotic livers, non-heart beating donor, elderly donors, donors with high inotrope requirements, long ischaemia times, high serum Na or donors with positive virology.\textsuperscript{10-12} Studies discovered that after liver transplantation, primary nonfunction and bad prognosis of liver transplantation were associated with the fatty liver condition of the transplantation.\textsuperscript{13-15} When a recipient accepted a donor liver with 25-30% fatty liver, the postoperative transaminases increased, bile production decreased, early bleeding rate increased (first 3 days) and 4-month, 2-year survivorship decreased.\textsuperscript{16} In this study, four of the cases were found to be fatty livers under the pathological slide examination, especially patient 4 which had a severe fatty liver condition. Two other factors included donors with high inotrope requirements and high serum Na or donors with positive virology. The study outcome showed that hypernatremia (sodium >155 mEq/l) donors tended to cause temporary primary non-function\textsuperscript{17}, and those marginal grafts increased postoperative morbidity or mortality.\textsuperscript{10,11}

Donor/recipient graft size mismatch with significant size difference was the third factor for IAH. There were four cases with donor livers more than twice as large as the recipient livers. Three hepatic edema cases were associated with fatty liver; however, the liver volume of patient 8 was 2300gm without being fatty. Part (380gm) of the left liver lobe was removed and 1920gm was the remaining liver volume. The end stage cirrhosis patients were complicated by the severe abdominal fluid conditions, which increased waist circumference and expanded abdominal cavity. Other than the severe abdominal conditions of patient 1 and 6, the other two patients did not produce much abdominal fluid during the surgery; therefore, the abdominal cavity volumes were unable to receive excessively oversized donor grafts. When the size of the liver graft was excessive, at the time of wound closure, IAH would increase pressure on the abdominal organs and cause bleeding. As a result, postoperative organ failure and complications were observed.

The last factor of IAH was bowel edema after portal vein clamping during transplantation. At end-stage cirrhosis, collateral circulation should be established for increased hepatic portal vein obstruction or portal hypertension; if collateral circulation was not established yet, at the time of connecting hepatic vessels during the liver transplantation, partial or complete clamping would be required on the inferior vena cava and hepatic portal vein, which easily led to bowel edema. Patient
9 was a Hepatitis B carrier. The acute onset complicated by acute liver failure led to severe hepatic encephalopathy. The disease progressed rapidly without collateral circulation. Emergency LDLT was performed with 66 minute portal vein clamping and 26 minute inferior vena cava clamping in the surgery. Severe bowel edema complicated by IAH resulted.

When severe IAH/ACS events occurred, the medical treatment aimed to reduce the intra-abdominal volume and increase abdominal wall compliance; therefore, early abdominal catheterization or intra-abdominal exploratory laparotomy for blood clots and fluid removal were the usual treatment. The condition of IAH/ACS could not be improved effectively. In contrast, using the mesh technique described in this paper to close the wound may improve the abdominal wall compliance. However, complications were also observed with mesh application. For patient 5, high fever and intra-abdominal infection were observed on Day 17 of the mesh application; after the mesh removal surgery, the infection symptoms improved immediately. Thus, the remaining three cases all removed mesh from the abdominal cavity within 14 days and no infection symptom was observed.

**Evaluation and critical care**

When end-stage cirrhosis patients received liver transplantation, their cardiopulmonary function may appear with hyperdynamic circulation (high cardiac output and index), cardiac dysfunction, hepatic hydrothorax, pulmonary edema, portopulmonary hypertension (PPH) and hypoxemia. However, when IAH/ACSIAP increased above 25mmHg, intrathoracic pressure, peak and mean inspiratory pressure and central venous pressure (CVP) would also increase, whereas cardiac output and index, tidal volume and intrarenal blood flow would decrease. When liver transplantation had been complicated by IAH/ACS, hypodynamic circulation would decrease cardiac output and index and tidal volume. Patients would present with tachycardia, poor peripheral perfusion, hypoxia, hypercarbia, atelectasis, acidosis and shock at the end. It is a severe change in symptoms. In the aspect of nursing, close monitoring is required on hemodynamics and ventilator changes; early detection and notification to the doctor may prevent disease progression and organ failure due to rapid management or decompression surgery.

Renal dysfunction may be preoperative or postoperative. Typical preoperative renal failure is caused by end-stage cirrhosis, hepatorenal syndrome. Postoperative renal dysfunction includes severe graft dysfunction, primary non-function, septic shock, ACS and nephrotoxic drugs, especially antimicrobials, IAH (reduced renal blood flow and glomerular filtration rate) and immunsuppressants that may damage the renal functions. Postoperative immunosuppression with calcineurin inhibitors (cyclosporine and tacrolimus) is nephrotoxic. When patients appear with renal dysfunction, the dose of calcineurin inhibitors can be reduced and keep the slightly lowered concentration in the blood (under the condition of no acute rejection), preventing acute renal failure. Therefore, in nursing, regular measurements of waist circumference and IAP, monitoring urine volume, measuring serum immunosuppressant concentration and renal function may prevent renal dysfunction or acute renal failure earlier.

The major cause of death for liver transplantation is infection. Infection agents include bacteria, virus, fungi or parasites. Before the surgery, infections may occur in weak recipients with low immunity; the infection may easily occur on those recipients during the transplantation. At the early stage of the surgery, the major infection agents are bacteria and fungi. Most postoperative infections affect the abdominal or pulmonary cavity. During the surgery, preventive antibiotics will be administered to reduce onset rates of intra-abdominal and wound infections. However, either the second surgery or wound closure by mesh would increase the risk and opportunity of infection. Therefore, wound care must strictly follow the sterilized nursing procedure or remove the catheter as early as possible. Drainage volume, color, form and high fever or other infectious symptoms should be noted. This is the key for postoperative
care for transplantation associated infections.

All nurses around those patients must be alert at all time to avoid liver transplantation complicated by IAH/ACS. Kidney, lung and cardiovascular functions must be closely monitored, including any infection signs to prevent more severe postoperative complications developed by IAH/ACS. When postoperative patients appear with low urinary output, hypotensive shock, increased peak airway or intrathoracic pressure, the risk and problem of ACS must be seriously considered. We believe that by measuring IAP through the urethra, early detection is possible in patients at risk of ACS. Postoperative waist circumference increase and IAP measurement are monitored; when IAP remains over 20-25mmHg, new organ dysfunction or failure may occur. So nursing should emphasize risk evaluation and early detection of IAH/ACS clinical signs and symptoms.

Conclusions

This paper describes the application of mesh for wound closure when liver transplantation is complicated by IAH/ACS; this technique decreased IAP events, improved and relieved intra-abdominal organ and blood supply. In addition, incidence rates of cardiovascular, respiratory and renal system complications were decreased. Currently, the hospital uses a synthetic mesh as an intervention at the time of wound closure when the central venous pressure increases more than 5mmHg. The timing for the synthetic mesh removal mainly depends on the postoperative recovery condition of hepatic and bowel edema; also, in order to prevent infections, the mesh is removed by surgery 7-14 days postoperation. This paper evaluates the keypoints of nursing physiologically to assist early detection and prevention of IAH/CAS symptoms, complications and infections. Emergency surgery or treatment avoids further organ failure or severe infections. The techniques and experiences are shared for transplant surgeon and ICU medical team’s nursing reference.

References

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運用人工網膜在肝臟移植術後併發腹內高壓之探討：評估與重症照護

謝佳恩¹，林惠娟²，林國華³，林佳正³，
林屏沂⁴，王思涵⁵，陳堯俐⁵

摘要

本文主要在探討在病患於肝臟移植術後併發腹內高壓或腹腔腔室症候群，接受使用人工網膜鋪以降低腹內壓之經驗及術後傷口護理照護。而肝臟移植術後引發腹內壓增加嚴重的因素有，1、在移植術中門脈阻斷導致腸腫脹，2、再灌注後的肝腫大，特別是 marginal grafts，3、捐贈者與受贈者肝臟比例的不配合，4、腹內出血，手術後或是嚴重凝血不全。針對彰化基督教醫院器官統計西元2002年至2010年，肝臟移植總共完成65例，分別屍體肝臟移植為32例，及活體部分肝臟移植33例。4例病患(3例屍體肝臟移植，1例活體部分肝臟移植)。除第一例，在術後在加護病房，發生腹內高壓或腹腔腔室症候群，並導致急性腎臟衰竭或是呼吸衰竭(血中二氧化碳過高)之情況，緊急採取剖腹探查手術。第二、三、四例則，在手術後將關閉腹腔傷口時，發現肺內壓與中心靜脈壓力急遽上升，無法再繼續進行傷口關閉而直接使用人工網膜。目前本院人工網膜時機，在關閉傷口縫合時，若中心靜脈壓力上升超過>5mmHg情形，介入使用。約在使用人工網膜後，七至十四天移除，原因為第一是等至病患之肝臟與腸腫脹減輕，第二是避免感染情況發生。本文運用人工網膜在肝臟移植術後併發腹內高壓的使用，來降低腹內壓的方式，提供移植外科醫師與加護病房團隊的經驗參考。

關鍵詞：肝臟移植，腹內壓，腹腔腔室症候群，人工網膜在傷口處置

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