Presentations and management of different causes of chylothorax in children: one medical center’s experience

Chien-Heng Lin\textsuperscript{a,b}, Wei-Ching Lin\textsuperscript{b,c,d}, Jeng-Sheng Chang\textsuperscript{d,e,*}

\textsuperscript{a}Division of Pediatric Pulmonology, China Medical University Children’s Hospital, Taichung 404, Taiwan
\textsuperscript{b}Department of Biomedical Imaging and Radiological Science, College of Health Care to College of Medicine, China Medical University, Taichung 404, Taiwan
\textsuperscript{c}Department of Radiology, China Medical University Hospital, Taichung 404, Taiwan
\textsuperscript{d}School of Medicine, College of Medicine, China Medical University, Taichung 404, Taiwan
\textsuperscript{e}Division of Pediatric Cardiology, China Medical University Children’s Hospital, Taichung 404, Taiwan

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\textsuperscript{*}Corresponding author. Department of Pediatrics, Children’s Hospital, China Medical University Hospital, No. 2, Yu-Der Road, Taichung 404, Taiwan.
E-mail address: d0669@mail.cmuh.org.tw (J.-S. Chang).

\textbf{1. Introduction}

Chylothorax is a condition of thoracic duct damage and chyle leakage from the lymphatic system into the pleural space. A diagnosis of chylothorax is made when an analysis of the pleural fluid content finds that triglyceride $> 1.1 \text{ mmol/l}$, the absolute white cell count $> 1,000/\text{mm}^3$, with a lymphocyte fraction $> 80\%$ [1, 2].

The etiologies of chylothorax in children are usually divided into four categories: trauma (including surgery), idiopathic or congenital, malignancy, and miscellaneous disorders [3]. The clinical courses vary substantially among the different causes of chylothorax. Postoperative complications of cardiothoracic surgery are the leading causes of chylothorax in children [2]. The congenital malformations of the pulmonary or thoracic lymphatic system, which are associated with some dysmorphic syndromes, are relatively rare causes for chylothorax [2, 4]. In adults, thoracic or neck trauma, or tumors occupying the upper thoracic aperture are the most common causes of chylothorax [5-7]. Treatment of chylothorax includes repairing the underlying condition(s), giving proper medication, and surgical intervention(s) [2, 4].

This study is aimed at reviewing pertinent medical records to explore the etiologies and characteristics of patients of chylothorax that were admitted to a medical center.

\textbf{2. Materials and methods}

We retrospectively collected and analyzed all of the patients with a chylothorax diagnosis in our hospital database from the years 1995 to 2005. Clinical information of age, sex, gestation age, underlying disease(s), clinical presentation, laboratory data of pleural fluid, duration of chest tube drainage, volume of pleural
Although chylothorax occurred in 14 of the total 22 patients (63.6%) due to a complication from cardiothoracic surgery (Table 1), it occurred in only 3.8% of all 363 cardiothoracic surgeries that were performed in the time period being considered. The median number of postoperative days before diagnosing clinically evident chylothorax were 4.5 days, though it was noted in 7 patients within the first 48 hours.

Congenital chylothorax occurred in five patients (22.7%, Table 2). Two cases were due to a complication from neuroblastoma (9.1%, Table 3), and one (4.6%) was from congenital nephrotic syndrome. Prenatal ultrasound studies observed chylothorax in the other two patients, and sono-guided thoracentesis was undertaken in one of the two fetuses at a gestational age of 32 weeks. The patient with congenital nephrotic syndrome was found to suffer from bilateral chylothorax at birth (male, 3000 g at 36 weeks of gestation). The triglyceride concentration in his pleural fluid was 2.1 mmol/l, and the total number of cells in chylous was 4980 cells/ml. Because of acute renal failure, a continuous arteriovenous hemofiltration (CA VH) was established soon after birth. However, the pleural effusion continued in large amount, and a pediatric surgeon was consulted for a pleurodesis procedure on day 18 of life. In the end, the patient died of end stage renal failure and refractory hypotension on day 24 of life.

After a 5-year follow-up, eighteen patients are still alive without recurrent chylothorax, and the mortality rate is 18.2% (2 passing away from neuroblastomas, 1 from nephrotic syndrome, and 1 from total anomalous pulmonary venous return). Thus, there was no mortality directly related to the chylothorax.

### 3. Results

The median age of the 22 total patients was 11.5 months, with their range being from 1 day to 3 years. The female to male ratio was 15 to 7. Seven patients suffered right side chylothorax (32%), nine suffered left side (41%), and 6 had bilateral (27%). Aside from two patients with diagnostic tapping, the first day drainage of chyle in the other 20 patients was between 33 to 890 ml (median: 240 ml).

All patients were treated initially with NPO, a diet of low fat medium chain triglycerides, and TPN. The median and mean duration of chest tube drainage in the 20 patients was 20 and 21.2 days, respectively (with a range of 2 to 31 days). The mean drainage duration in cardiothoracic surgery group, congenital chylothorax group, and neuroblastoma group were 21.2, 20.8, and 25.7 days, respectively. However, there were 3 patients (13.6%) that needed surgical intervention (2 with pleural peritoneal shunt and 1 with pleurodesis) after chest tube drainage was unsuccessful.

### 4. Discussion

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### Table 1 − Data of Postoperative chylothorax after cardiothoracic surgery in children.

<table>
<thead>
<tr>
<th>Case</th>
<th>Age/Sex</th>
<th>Underlying disease</th>
<th>Type of operation</th>
<th>Triglyceride levels in pleural fluid (mmol/l)</th>
<th>Total number of cells and lymphocytes (cells/ml)</th>
<th>Site</th>
<th>Drainage days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1*</td>
<td>5mo/F</td>
<td>VSD + PS, TGA</td>
<td>Total repair</td>
<td>1.8</td>
<td>2350</td>
<td>Left</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>1d/F</td>
<td>TGA</td>
<td>Arterial switch</td>
<td>4.4</td>
<td>2550</td>
<td>Right</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>1yr/M</td>
<td>VSD</td>
<td>VSD repair</td>
<td>10.5</td>
<td>2398</td>
<td>Bilateral</td>
<td>6</td>
</tr>
<tr>
<td>4*</td>
<td>1mo/M</td>
<td>VSD + ASD</td>
<td>Closure of ASD/VSD</td>
<td>2.1</td>
<td>1106</td>
<td>Bilateral</td>
<td>35</td>
</tr>
<tr>
<td>5</td>
<td>7mo/F</td>
<td>ECD,</td>
<td>ECD repair</td>
<td>2.5</td>
<td>2650</td>
<td>Right</td>
<td>No drainage</td>
</tr>
<tr>
<td>6</td>
<td>1mo/M</td>
<td>CDH</td>
<td>CDH repair</td>
<td>1.4</td>
<td>987</td>
<td>Left</td>
<td>9</td>
</tr>
<tr>
<td>7</td>
<td>8mo/F</td>
<td>TOF</td>
<td>TOF repair</td>
<td>5.9</td>
<td>1108</td>
<td>Bilateral</td>
<td>R:30, L:29</td>
</tr>
<tr>
<td>8#</td>
<td>4d/F</td>
<td>TAPVR</td>
<td>Correction of TAPVR</td>
<td>14.7</td>
<td>8700</td>
<td>Bilateral</td>
<td>R:32, L:4</td>
</tr>
<tr>
<td>9</td>
<td>2yr/F</td>
<td>Large PDA</td>
<td>PDA ligation</td>
<td>1.6</td>
<td>1658</td>
<td>Left</td>
<td>28</td>
</tr>
<tr>
<td>10</td>
<td>20d/F</td>
<td>PDA</td>
<td>PDA ligation</td>
<td>8.8</td>
<td>6790</td>
<td>Left</td>
<td>28</td>
</tr>
<tr>
<td>11</td>
<td>1d/F</td>
<td>TGA</td>
<td>Arterial switch</td>
<td>1.4</td>
<td>3709</td>
<td>Left</td>
<td>20</td>
</tr>
<tr>
<td>12</td>
<td>2yr/M</td>
<td>RV hypoplasia</td>
<td>Hemi-Fontan</td>
<td>2.3</td>
<td>1146</td>
<td>Right</td>
<td>16</td>
</tr>
<tr>
<td>13</td>
<td>1yr/F</td>
<td>ECD + TOF</td>
<td>Repair of ECD, TOF</td>
<td>2.2</td>
<td>3799</td>
<td>Left</td>
<td>19</td>
</tr>
<tr>
<td>14</td>
<td>3yr/F</td>
<td>VSD</td>
<td>VSD repair</td>
<td>2.3</td>
<td>9780</td>
<td>Left</td>
<td>7</td>
</tr>
</tbody>
</table>

* Performed pleural-peritoneal shunting, #: expired on postoperative day 49
M = male, F = female, R = right, L = left, VSD = ventricular septal defect, ASD = atrial septal defect, EDC = endocardial cushion defect, CDH = congenital diaphragm hernia, TOF = Totalogy of Fallot, TAPVR = Total anomalous pulmonary venous return, PDA = patent ductus arteriosus, TGA = transposition of the great arteries, RV = right ventricular.
In children, it is the most common form of pleural effusion in non-surgical neonates [8]. Haines C et al. reported incidence of children with chylothorax in the UK was 0.0014% [9]. There are multiple etiologies of chylothorax in children. In this survey, postoperative chylothorax was found to be the most common etiology, followed by congenital chylothorax, malignancy, and miscellaneous disorders.

4.1. Postoperative chylothorax

In children, the reported incidence of chylothorax after cardiothoracic surgery is between 0.85% and 6.6% [2, 8]. In a national, multicenter study, which involved 172 children with chylothorax and was reported by Haines C et al., the incidence of chylothorax following a cardiac surgical procedure was 3.2%, which is almost the same percentage as our study (3.8%) [9]. In their report, 65.1% of the cases of chylothorax in children were associated with cardiac surgical procedures, with a neonatal diagnosis being the second most common (22.7%) [8]. In our study, the most common etiology was found to be due to the complications of cardiothoracic surgery (63.6%), which is also similar to Haines C et al. survey.

A high incidence of chylothorax was observed in heart transplantation and Fontan procedures in a study by Chan EH et al. [10]. Undoubtedly, heart transplantation is associated with increased trauma to the chest cavity and Fontan (or cavopulmonary anastomosis) procedures will elevate superior vena cava pressure, both of which can result in a higher risk for chylothorax. In the Haines C et al. study, the Fontan procedure and repair of Tetralogy of Fallot (TOF) are the two most common procedures found to have led to postoperative chylothorax [9]. However, in our study, patent ductus arteriosus ligation and repair of the ventricular septal defect (VSD) are the two most common procedures found to cause postoperative chylothorax. The risk factors for cardiothoracic surgery related chylothorax in children are: the complicated nature of the procedure, secondary chest tube closure, younger age, lower body weight, genetic syndromes, vein thrombosis, lengthy cardiopulmonary bypass, X-clamp time, and higher annual hospital volume [11, 12].

4.2. Congenital/idiopathic

Congenital chylothorax can be classified either with congenital lymphatic malformations, such as lymphangiomatosis or lymphangiectasia, or associated with syndromes, such as Down syndrome, Noonan syndrome, Turner syndrome, hydrops fetalis, yellow nail syndrome, and other rare syndromes [4]. In the Haines C et al. study, 16.8% of the chylothorax cases had a recognized congenital anomaly, with Down syndrome (10.5%) and Noonan syndrome (4%) [9]. Approximately 5 to 10% of chylothoraces are idiopathic, and the cause(s) in such a setting are unknown [13]. Idiopathic chylothorax is the most common form of pleural effusion in the first few days of life and 50% of newborns with idiopathic chylothorax develop symptoms within 24 hours of birth [13]. As well, cases without a clear explanation for the occurrence of chylothorax can be considered congenital chylothorax. In our study, 5 patients (22.7%) with congenital chylothorax were idiopathic without an associated syndrome.

4.3. Malignancy

Malignancies, while one of the most common causes of chylothorax in adults, are a less prevalent cause in children. In the Staats et al. series, lymphoma accounted for most cases (52.6%) of chylothorax in adults [15]. In children, lymphoma is also the most common tumor associated with chylothorax (60% to 70% of cases), and it may be the presenting symptom [2, 16, 17]. Other malignancies include neurogenic, teratoma, Wilm, ovarian, and Kaposi sarcoma [2, 4]. In this study, the 2 cases of malignancy-related chylothorax were patients with neuroblastoma, and they

<table>
<thead>
<tr>
<th>Case</th>
<th>Age/Sex</th>
<th>GA/BBW (gm)</th>
<th>Triglyceride levels in pleural fluid (mmol/l)</th>
<th>Total number of cells and lymphocytes (cells/ml)</th>
<th>Site</th>
<th>Drainage days</th>
<th>Prognosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2yr/F</td>
<td>39/4000</td>
<td>9.8</td>
<td>1460</td>
<td>Left</td>
<td>22</td>
<td>Expired on day 55</td>
</tr>
<tr>
<td>2*</td>
<td>5d/F</td>
<td>39/3250</td>
<td>1.6</td>
<td>2479</td>
<td>Right</td>
<td>No drainage</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1d/M</td>
<td>38/3305</td>
<td>2.1</td>
<td>3790</td>
<td>Right</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>9d/M</td>
<td>38/3200</td>
<td>3.9</td>
<td>5690</td>
<td>Right</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1d/M</td>
<td>37/3350</td>
<td>1.5</td>
<td>1180</td>
<td>Bilateral</td>
<td>31</td>
<td></td>
</tr>
</tbody>
</table>

* Intrapartum sono-guided thoracentesis was performed at GA 32 wks.

**Table 2 − Data of children with congenital chylothorax.**

<table>
<thead>
<tr>
<th>Case</th>
<th>Age/Sex</th>
<th>GA/BBW (gm)</th>
<th>Triglyceride levels in pleural fluid (mmol/l)</th>
<th>Total number of cells and lymphocytes (cells/ml)</th>
<th>Site</th>
<th>Drainage days</th>
<th>Prognosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4d/M</td>
<td>39/4000</td>
<td>9.8</td>
<td>1460</td>
<td>Left</td>
<td>22</td>
<td>Expired on day 55</td>
</tr>
<tr>
<td>2*</td>
<td>5d/F</td>
<td>39/3250</td>
<td>1.6</td>
<td>2479</td>
<td>Right</td>
<td>No drainage</td>
<td></td>
</tr>
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<td>3</td>
<td>1d/M</td>
<td>38/3305</td>
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<td>Right</td>
<td>25</td>
<td></td>
</tr>
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<td>9d/M</td>
<td>38/3200</td>
<td>3.9</td>
<td>5690</td>
<td>Right</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1d/M</td>
<td>37/3350</td>
<td>1.5</td>
<td>1180</td>
<td>Bilateral</td>
<td>31</td>
<td></td>
</tr>
</tbody>
</table>

**Table 3 − Two children with chylothorax associated with neuroblastomas.**
both expired.

4.4. Miscellaneous disorders

The various other medical conditions that have been associated with chylothorax are classified as miscellaneous, and these miscellaneous causes are more common in adults than children [18]. Granulomatous infections such as tuberculosis, histoplasmosis, and sarcoidosis are associated with chylothorax because of lymphadenopathy obstructing the thoracic duct [4, 19, 20]. In some patients with chylous ascites, which in turn is related to a primary abdominal process such as nephrotic syndrome, hypothyroidism, cirrhosis of the liver, abdominal operations, and pancreatitis, chylothorax can occur [18, 21]. Other causes include mediastinal radiation therapy, staphylococcal discitis, and Henoch-Schönlein purpura [22-24].

In our study, one patient with a rare case of congenital nephrotic syndrome had chylothorax; the mechanism was that chylous ascites in the peritoneum transferred to the pleural cavity through diaphragmatic defects because of the negative intrathoracic pressure during inspiration.

4.5. Treatment

The goal of the management of chylothorax is to relieve respiratory symptoms by drainage of the pleural fluid. After thoracocentesis is initially performed for diagnostic purposes, if the effusion is large and is compromising respiration, or there is a high possibility of recurrence, then a chest tube should be inserted for continuous drainage of the pleural space. The two most common agents aimed to reduce the production of chyle in patients with chylothorax are somatostatin and octreotide. Other agents include nitric oxide, etilefrine, tetracycline, talc, bleomycin, fibrin glue, and povidon-iodine, and OK-432 [4].

Surgical intervention, include thoracic duct ligation, pleurectomy, pleuropertitoneal shunts, pleurectomy, and pleural abrasion, sometimes become necessary when medical therapy fails. There is currently no consensus on the timing of surgery [2, 4]. However, most recommend a period 3 to 4 weeks of conservative management before undertaking surgical intervention [1, 2, 8].

All of the patients in our study were treated with conservative management initially, and chest tube drainages were required in 20 of them. Only 3 patients needed surgical intervention subsequently.

4.6. Prognosis

The mortality rate from chylothorax has improved because of the more aggressive management plans that have been adopted [5]. The mortality rate is almost 10% in children with chylothorax developing after cardiac surgery, and 18% for those with neonatal diagnoses [9]. Malignant chylothorax, chronic debilitating chylothorax, and bilateral chylothoraces have unfavorable prognoses [25]. In our study, the mortality rate of patients with chylothorax was 18.2%; however, these patients died of underlying diseases that were unrelated to chylothorax.

5. Conclusion

In our study, the majority of chylothorax in children resulted from complications of cardiothoracic surgery, followed by congenital/idiopathic, malignancy, and other less common conditions. Diagnostic thoracentesis for pleural fluid analysis should be done to provide clues for how best to manage chylothorax. The prognosis of chylothorax is good except for those cases where the cause is from other malignancies, which will lead to a high mortality rate.

Conflicts of interest statement

The authors declare that there are no conflicts of interest.

REFERENCES

[15] Staats BA, Ellefson RD, Budahn LD, Dines DE, Prakash UBS, Of-


