Ultrasound evaluation of complications after cardiovascular surgery in pediatric patients: A case series

Takahiro Hosokawa1, Sio Suzuki2, Yutaka Tanami1, Yumiko Sato1, Yoshihiro Ko3, Koji Nomura3, Eiji Oguma1, Yoshitake Yamada4

1Department of Radiology, Saitama Children’s Medical Center, Saitama, 2Department of Cardiology, Saitama Children’s Medical Center, Saitama, 3Department of Cardiovascular surgery, Saitama Children’s Medical Center, Saitama, 4Department of Radiology, Keio University School of Medicine, Tokyo, Japan

Abstract
In contrast to computed tomography, ultrasound can be performed without radiation exposure, repeatedly performed by the patients’ bedside. Hence, in this case series, we describe the evaluation of complications including hematoma, superficial surgical site infection, mediastinitis, and pseudoaneurysm associated mediastinitis using ultrasound in pediatric patients after cardiovascular surgery. To our knowledge, no previous reports have evaluated such complications using ultrasound. Ultrasound may be useful for the early diagnosis of these complications, and in the selection of subsequent examinations such as computed tomography, resulting in the early initiation of intervention.

Keywords: mediastinitis; cardiovascular surgery; congenital heart disease; ultrasound; surgical site infection

Introduction
In pediatric patients, cardiovascular surgery is mainly performed for congenital heart disease and two or three operations may be performed in the same case [1-3]. To date, some complications such as hematoma or surgical site infection including mediastinitis have been reported. These complications may be a life-threatening [4-8]. The mediastinitis after cardiovascular surgery sometimes results in failure to complete all necessary procedures due to vein occlusion and strict adhesion and it may be result in more severe complications such as pseudoaneurysm [1,9-11]. Therefore, for pediatric patients, accurate diagnosis of these complications and early intervention are important.

Previous studies have reported that computed tomography (CT) is useful for diagnosing complications such as such as hematoma, surgical site infection, mediastinitis and pseudoaneurysm associated mediastinitis [4,5,7,12-16]. However, to our knowledge, there have been no reports to evaluate these complications using ultrasound. In contrast to CT, ultrasound can be performed without radiation exposure. In addition, because the patients do not have stable circulation after cardiovascular surgery, it may be difficult to move them from the intensive care unit; therefore ultrasound is an advantage as it can be performed by the patients’ bedside [17,18].
Thus, the purpose of this case series demonstrated the utility of ultrasound imaging of various complications, including hematomata, surgical site infection, mediastinitis, and pseudoaneurysm associated mediastinitis in pediatric patients after cardiovascular surgery. In addition, we showed the sonogram with no complications in case 1.

**Case series**

The Ethics committee of our institution approved this retrospective study, and the requirement to obtain informed consent from the patients was waived.

**Case 1**

Case 1 was a 5-month-old male patient with no eventful clinical course. He underwent cardiovascular surgery for an atrioventricular septal defect at the age of 4 months. After 1 month, ultrasound screening was performed for evaluation of mediastinitis. Mediastinitis was not detected on ultrasound (fig 1).

**Case 2**

A male patient aged 5 years and 4 months underwent cardiovascular surgeries at 3 months old and 3 years 8 months old for pulmonary artery atresia and a ventricular septal defect. He later experienced erythema and pain at the incision site at the age of 5 years and 4 months. Ultrasound revealed wire within the cystic region (fig 2). Hemorrhagic serous fluid was aspirated and hematoma around the wire was confirmed.

**Case 3**

Case 3 was a 1-month old male patient. Cardiac surgery for atrial/ventricular septal defect was performed at 1 month old. After 10 days, a precordial mass was incidentally detected. Using ultrasound, a cystic lesion was revealed and CT was recommended. CT revealed a cystic mass with ring enhancement in the anterior wall (fig 3). To prevent invasion of the pulmonary artery, surgical treatment was selected. The patient was diagnosed with hematoma.

![Fig 1](image1.png)

**Fig 1.** Imaging findings in a 5-month-old male patient with no eventful clinical course: a) frontal chest radiograph shows wires at the sternum; b) transverse sonogram at line b in image a shows that no dehiscence between the right and left separated sternum (dotted line). The sternum without ossification appears as a low echoic structure (dotted line); c) slightly lower site than that in b. Transverse sonogram at line c in a describing no dehiscence of the sternum (dotted line) and the wire appears as a hyperechoic line around the sternum (continuous line); d) slightly lower site than that in c, at line d, transverse sonogram showing ossification (continuous line) at the center of the sternum (dotted line); e) sagittal sonogram at the midline (line e in fig a) showing no fluid behind the sternum. There is no soft tissue mass between the sternum and the heart. The sternum is indicated by the dotted line. Ossified centers appear as high echoic structures (continuous line) within the sternum.

![Fig 2](image2.png)

**Fig 2.** Imaging findings in case 2: a) frontal chest radiograph shows wires at the sternum; b) sagittal sonogram at line b in a describing a cystic mass (arrows) on the sternum (dotted line). The wire appears as a hyperechoic line (continuous line) within the cystic mass. The ossified sternum appears as a hyperechoic structure and acoustic shadows can be observed behind the sternum; c) transverse sonogram at line c in fig a showing a cystic mass (arrows) and the wire appears as a hyperechoic line (continuous line). The dotted line indicates the sternum.
**Case 4**

Case 4 was a 1-month-old female patient. Surgical repair for transposition of the great arteries was performed at 10 days after birth. Twenty days after operation, consistent fever was observed and ultrasound evaluation was performed. Based on the ultrasound findings, surgical site infection was suspected and CT was recommended to determine the occurrence of deep sternal wound infection. CT revealed a low attenuation area behind and at the lower end of the sternum (fig 4). Although it was difficult to differentiate postoperative change from surgical site infection on CT, surgical aspiration was performed at the lower end of the sternum based on the sonographic findings. Surgical site infection with methicillin-resistant *Staphylococcus aureus* was confirmed.

**Case 5**

Case 5 was a female aged 4 years and 2 months. Surgical repair for Tetralogy of Fallot was performed at the age of 3 months. Subsequently, repeated surgical site infection was observed. She experienced erythema and pain at the incision site at 4 years and 2 months of age. Ultrasound revealed fluid collection at the incision site and CT was recommended. Based on the CT findings, incision drainage was selected and the patient was diagnosed with infection of the sternum (fig 5).

**Case 6**

In a male patient aged 1 year and 6 months after surgical repair for Ebstein’s anomaly, superior vena cava stenosis was detected. Surgical repair was performed at
1 year 6 months of age. From 10 days postoperatively, consistent fever was observed. Ultrasound was performed and fluid collection behind the sternum was revealed. CT was performed for evaluation. After diagnosis of mediastinitis, surgical debridement was performed. At 2 weeks postoperatively, a follow-up sonogram revealed a pseudoaneurysm within mediastinum. After performing ultrasound and CT, surgical repair was selected (fig 6).

Discussions

In this case series, we demonstrated the utility of ultrasound evaluation in various complications including hematoma, surgical site infection, mediastinitis and pseudoaneurysm associated mediastinitis in pediatric patients after cardiovascular surgery. Ultrasound was not only reported to be useful for accessing the abscess and for performing drainage, but may also be useful for the ear-
ly diagnosis of complications in pediatric patients who have undergone cardiac surgery [19,20]. In addition, ultrasound can be performed repeatedly and this advantage was important for the detection of complications such as pseudoaneurysm, which were sometimes not accompanied by associated symptoms (see case 6). According to our current cases, ultrasound may be recommended in pediatric patients in whom various complications are suspected after cardiovascular surgery.

In our pediatric patients, the fluid collection behind insufficient sternal ossification could be visualized by ultrasound (cases 3, 4, and 6), whereas ossified bone structures in adult patients makes acoustic shadows and blind areas. In previous studies, sternal destruction and fluid correction were reported to be important factors in the diagnosis of mediastinitis [21-23]. Although bone destruction may be difficult to detect with ultrasound, fluid collection or dehiscence can be detected with this modality between the right and left separated sternum (case 4, 5).

However, despite surgeon-led evaluation of the risk factors and improved surgical timing or devices to prevent complications, it can still occur [24-29]. In the short interval between the operation and the imaging examination, the differentiation of findings of mediastinitis and operative change is reported to be difficult [4,5,12]. In current cases, there were two cases of hematoma rather than mediastinitis (case 2, 3). The differentiation of infection and hematoma may also be difficult by using imaging modalities such as ultrasound and CT alone. Physical examination findings of fever and erythema at the incision site are important for the diagnosis of mediastinitis (case 4, 5) [8,30].

Although the current case series demonstrates the utility of ultrasound for the evaluation of complications after cardiovascular surgery in pediatric patients, there have been no systematic studies of the use of ultrasound in the diagnosis of mediastinitis in pediatric patients. Further studies including ultrasound and other modalities, such as magnetic resonance imaging, may be required to support our results.

Conclusion

In this case series, we demonstrated the utility of ultrasound evaluation of various complications, including hematoma, surgical site infection, mediastinitis, and pseudoaneurysm associated mediastinitis in pediatric patients after cardiovascular surgery. According to our current cases, ultrasound may be recommended in pediatric patients in whom certain complications after cardiovascular surgery are suspected.

Conflict of interest: none

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