行政院國家科學委員會補助專題研究計畫成果報告

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※右心室雙出口之三度空間立體電子射束電腦斷層心血※
※管攝影 (2/2) – 第二年 ※

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執行期間： 90 年 08 月 01 日至 91 年 07 月 31 日

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右心室雙出口之三度空間立體電子射束電腦斷層心血管攝影（2/2）－第二年結案報告

Three-Dimensional Electron Beam Computed Tomography Cardiovascular Angiogram in Double Outlet of Right Ventricle (2/2) – Second Year Final Report

計畫編號：NSC 89-2314-B002-307-M08
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一、中文摘要

本計劃的目的為評估電子射束電腦斷層掃描攝影（EBCT）及其三度空間立體組像在先天性心臟病中右心室雙出口（DORV）的應用。在過去 24 個月中，吾等收集了 43 個 DORV 的病例(男：女=26：17；年齡=5 天~10 歲 10 月)。所有的病人都是接受靜脈注射顯影劑之 EBCT 的檢查，且其影像取得皆位於終心舒張期時。重組的 3D 影像採用漸層陰影的表面呈現模式。共有主動脈下（n=12），肺動脈下（n=17），非共通性（n=13）以及雙共通性(n=1)，這幾種型式的心室中隔缺損（VSD）被看到。主動脈下 VSD 者，其 VSD 的上緣就剛好落在主動脈環的下方。肺動脈下 VSD 型者，同理其 VSD 的上緣就會剛好落在肺動脈環的下方。非共通性 VSD 型者，其 VSD 的上緣遠離任何一個大動脈環以及心出口隔和大動脈根。而雙共通性 VSD 型者，其兩大動脈環剛好就座落於 VSD 的上緣。進一步的 3D 組像，藉由將心臟的前面部份移除，以供更加能直接評估心臟內部的立體結構：心室出口隔、大動脈環根以及其與 VSD 之立體相關位置和關係。

關鍵詞：心室中隔缺損；右心室雙出口；小孩；三度空間立體影像；電腦斷層掃描攝影。

ABSTRACT

To evaluate the clinical usefulness of electron beam computed tomography (EBCT) and its reconstructed 3D imaging in demonstrating cardiac anatomy in patients with double-outlet right ventricle (DORV). In the past 24 months, 43 cases (boy : girl = 26 : 17; age = 5 days ~ 10-year-10-month) with DORV were analyzed. All EBCT images were taken at the end-diastolic phase of the cardiac cycle with intravenous injection of iodinated contrast medium. 3D reconstructed EBCT pictures were created with gradient shading surface rendering. There were sub-aortic (n=12), sub-pulmonary (n=17). non-committed (n=13) and double committed (n=1) subtypes ventricular septal defect (VSD). In sub-aortic type, pulmonary annulus located just above the VSD. In sub-pulmonary type, pulmonary annulus located just above the VSD. In non-committed type, the upper margin of VSD far away from lower margin of the outlet septum and any great arteries. In double-committed type, the upper margin of VSD just supports annulus of both great arteries. Moreover, by partially removed the anterior parts of the heart let us can evaluate the inside cardiac chambers directly for details on the ventricular outlet, great arterial root and VSD relationships.

Keywords: Ventricular Septal defect; Double Outlet of Right Ventricle; Children; 3D; Computed tomography.

二、BACKGROUND & PURPOSE

DORV accounts for approximately 1.3% of all congenital heart disease. A VSD is generally present in DORV, and its proximity to the arterial valves as well as the spatial relationship of aorta and pulmonary trunk are the major determinants for surgical intervention. Either arterial switch or ventricular rerouting or other procedures are done [1-5]. The complexity of these malformations requires a highly individualized examination and flexible approach [6-8]. However, we had problems of: (1) How to delineate accurately the ventriculo-arterial connection in order to diagnose DORV. How to demonstrate the 3D spatial relationship of aorta and pulmonary trunk. (2) How to diagnose the exact location of VSD, and its relationship between this defect and arterial valves. All of these are important indicators for selecting appropriate surgical strategies.

With 3D reconstruction of EBCT, it provides a vivid impression of the cardiac anomaly as a whole. In this second year study, we focus on the relationship of internal cardiac structures by removing of the frontal segment from the 3D heart. This information is crucial for surgeon to plan his approach during operation.

三、RESULTS

Establish 3D Internal Heart Protocol

3D reconstruction was performed on an independent workstation using an available software package. The hearts were extracted from bony thorax by manually drew a restrictive region of interest that included cardiovascular structures. These regions of interest were stacked to create a new volumetric data. Gradient shading surface rendering protocol was adopted. Contrast filled chambers/vascular lumens were further "classified" (segmented) using interval thresholds based on Hounsfield numbers. The transparency of the myocardium/vascular wall was set at 0% whether that of chambers/vascular lumens at 1~3%, in order to see through. These reconstructed 3D pictures were viewing from the true frontal aspect. Incrementally partial removal of the ventral part of the reconstructed heart was performed for viewing the inner structures.

3D Relationship of Great arteries, Annulus & Outlet septum in Different VSD subtypes

From three-dimensional EBCT internal cardiac view, we found a close interaction between the relationship of the both great arteries, orientation of outlet septum and the sub-typing of VSD. In cases with ***sub-aortic*** type VSD (Figure 1), the aortic annulus located right posterior to pulmonary annulus. The outlet septum all ran in oblique transverse plane. In case with ***sub-pulmonary*** type VSD (Figure 2), aortic annulus located right anterior to pulmonary annulus. Their outlet septa ran in sagittal plane. In ***non-committed*** type VSD (Figure 3), aortic annulus could locate both right anterior and right posterior to pulmonary annulus. Their outlet septa could run both in sagittal and oblique transverse planes. When the outlet septum ran in sagittal plane, then aortic annulus would locate right anterior to pulmonary annulus. This picture is similar to the typical sub-pulmonary type VSD. However, when the outlet septum ran in oblique transverse plane, then aortic annulus would locate right posterior to pulmonary annulus. The picture mimicked a sub0aortic type VSD. Nevertheless, the upper margin of VSD was below the lower margin of the outlet septum and away from the orifices of great arteries. The only one

case with ***double-committed*** type VSD (Figure 4) revealed the upper margin of this large VSD just under both great arteries. She had hypoplastic outlet septum. The aortic annulus located right posterior to the pulmonary annulus.

四、DISCUSSION

With this second year results, the diagnosis of the all types of VSD in DORV could be judged from the vicinity of the upper margins of VSD to the great arteries. The 3D Internal Heart view provides well delineating the 3D relationship of the outlet septum, inlet septum, cornus as well as the relationship of the great arterial annulus to the VSD. Such demonstration answers the most important questions about the relationship between VSD and roots of great arteries. This information is mandatory in deciding the way surgeon can do in surgical correction of the patient.

五、REFERENCES

1. Yoo SJ, Lim TH, Park IS, Hong CY, Song MG, Kim SH, Lee HJ. MR anatomy of ventricular septal defect in double-outlet right ventricle with situs solitus and atrioventricular concordance. Radiology 1991;181(2):501-5.
2. Tchervenkov CI, Marelli D, Beland MJ, Gibbons JE, Paquet M, Dobell AR. Institutional experience with a protocol of early primary repair of double-outlet right ventricle. Ann Thorac Surg 1995;60:S610-3.
3. Lui RC, Williams WG, Trusler GA, Freedom RM, Coles JG, Rebeyka IM, Smallhorn J. Experience with the Damus-Kaye-Stansel procedure for children with Taussig-Bing hearts or univentricular hearts with subaortic stenosis. Circulation 1993;88:170-6.
4. Mavroudis C, Backer CL, Muster AJ, Rocchini AP, Rees AH, Gevitz M. Taussig-Bing anomaly: arterial switch versus Kawashima intraventricular repair. Ann Thorac Surg 1996;61(5):1330-8.
5. Lev M, Bharati S, Meng CCL, Liberthson RR, Paul MH, Idriss F. A concept of double-outlet right ventricle. J Thorac Cardiovasc Surg 1972;64:271-81.
6. Howell CE, Ho SY, Anderson RH, Elliott MJ. Fibrous skeleton and ventricular outflow tracts in double-outlet right ventricle. Ann Thorac Surg 1991;51(3):394-400.
7. Kleinert S, Sano T, Weintraub RG, Mee RB, Karl TR, Wilkinson JL. Anatomic features and surgical strategies in double-outlet right ventricle. Circulation 1997;96(4):1233-9.
8. Stellin G, Ho SY, Anderson RH, Zuberbuhler JR, Siewers RD. The surgical anatomy of double-outlet right ventricle with concordant atrioventricular connection and noncommitted ventricular septal defect. J Thorac Cardiovasc Surg 1991;102(6):849-55.

六、SELF-EVALUATION

The result of this second year project revealed very consistent with the original proposal. Investigators have established a good protocol for 3D reconstruction of the internal cardiovascular structures. The expected goal has successfully achieved by setting up a practical guideline and vivid delineation for diagnose different types of VSD in DORV. The clinical application of this result is great. Because this information will provide surgeon a clear road map of diseased ventriculo-arterail junction before operation that help them decide a better manipulations.

七、FIGURES

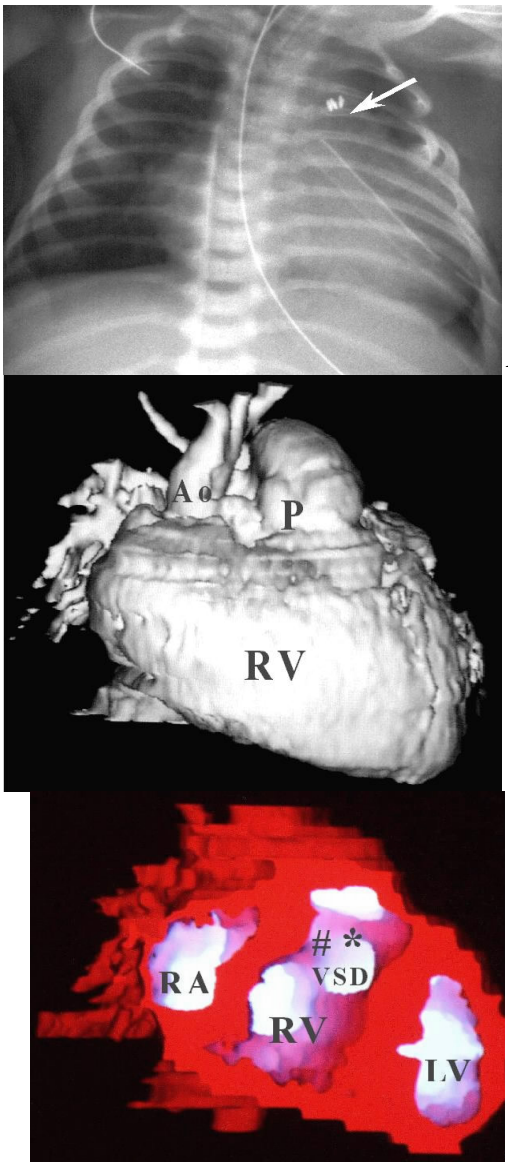

Figure 1. Sub-aortic type VSD of DORV. (A) CXR showed cardiomegaly. The pulmonary segment was engorged (arrow). (B) 3D CTA revealed both PT & Ao arose from the RV with dilated PT located left anterior (61^0) to Ao. (C) 3D inner cardiac view demonstrated the location of the VSD just under the orifice of Ao (#), the conus septum (*) ran in oblique horizontal plane. Ao=aorta; LV=left ventricle; PT=pulmonary trunk; RA=right atrium; RV=right ventricle; VSD=ventricular septum.

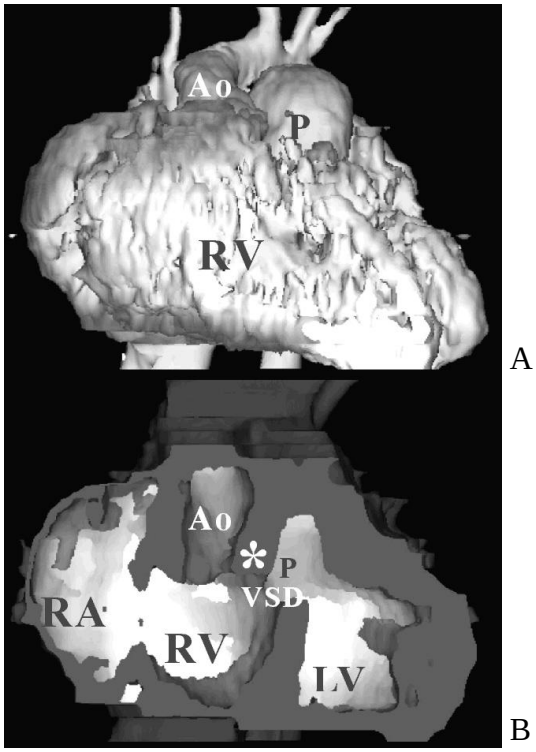

Figure 2. Sub-pulmonary type VSD of DORV. (A) 3D CTA revealed both PT & Ao arose from the RV with rather parallel relationship (130^0). (B) 3D inner cardiac view demonstrated the location of the VSD just under the opening of PT. But,, overriding of the PT to LV was noted. The conus septum (*) also ran in sagittal plane. Ao=aorta; LV=left ventricle; PT=pulmonary trunk; RA=right atrium; RV=right ventricle; VSD=ventricular septum

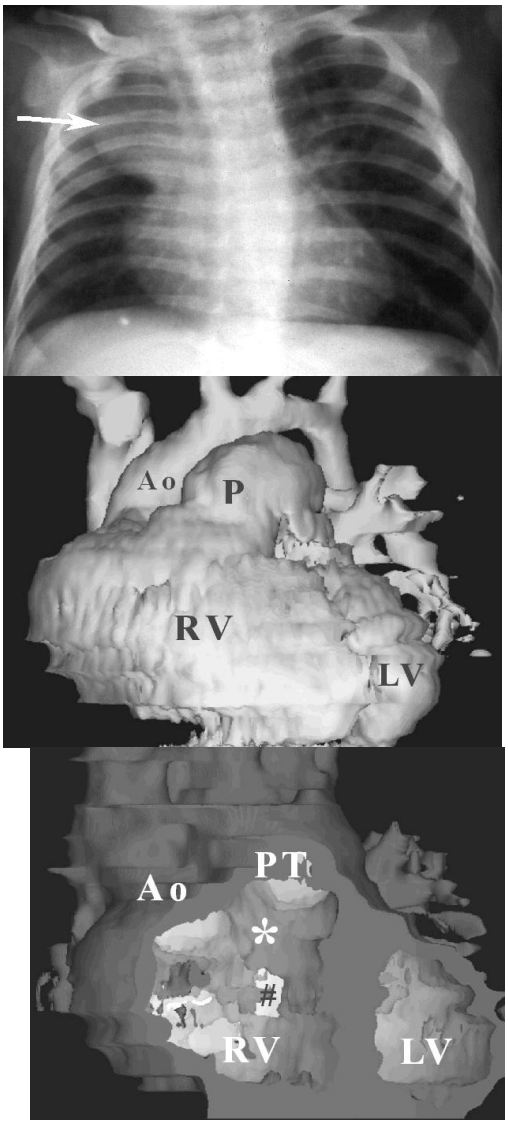

Figure 3. Non-committed VSD type of DORV. (A) CXR showed normal heart size with bulging right upper mediastinum (arrow) by prominent thymus. (B) 3D CTA revealed both PT & Ao arose from the RV with PT left anterior (58^0) to Ao. (C) 3D inner cardiac view demonstrated the location of the VSD(#) at the membranous septum away from both great arteries. The conus septum (*) ran in oblique coronal plane. Ao=aorta; LV=left ventricle; PT=pulmonary trunk; RV=right ventricle; VSD=ventricular septum.

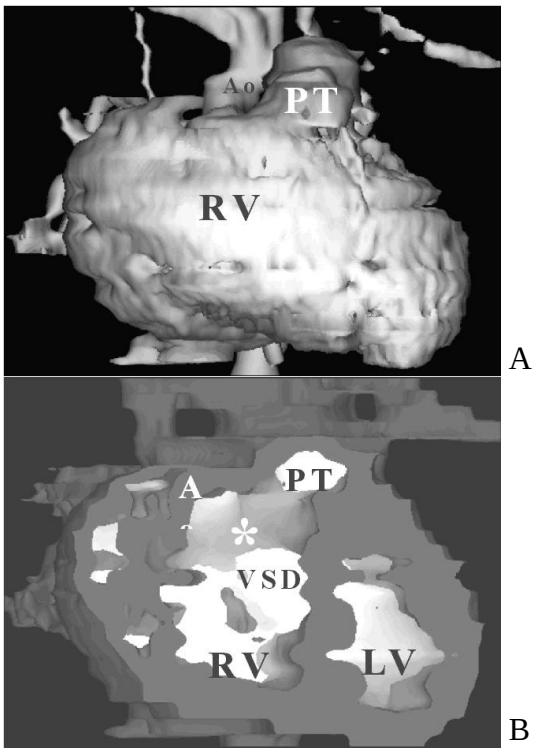

Figure 4. Doubly-committed VSD type of DORV. (A) 3D CTA revealed both PT & Ao arose from the RV with PT left anterior (31^0) to Ao. (B) 3D inner cardiac view demonstrated the upper margins of the VSD just benign both great arteries. The conus septum (*) formed a arch under both PT & Ao. Ao=aorta; LV=left ventricle; PT=pulmonary trunk; RV=right ventricle; VSD=ventricular septum.