Three-dimensional Echoencephalography in Infants

Kou ICHIHASHI¹, Sadayuki YANO², Mariko MOMOI¹

¹ Department of Pediatrics, Jichi Medical School
² Yano Children’s Clinic

We evaluated the clinical usefulness of three-dimensional (3-D) echoencephalography in infants. The transducer was placed on the anterior fontanel and all the sections were serially and automatically scanned in a few seconds. A 3-D image was constructed by an internal computer in a few seconds.

We could produce B-mode images at any direction, including those which could not be achieved via conventional methods. By using 3-D imaging, we could easily grasp the three-dimensional structure of the central nervous system. Further, we could measure ventricular volumes.

We concluded that 3-D echoencephalography in infants is very useful.

Key words: 3-D echoencephalography, Infant

Introduction

Recently, the device for three-dimensional (3-D) ultrasonography has become practical for clinical use in the regions of digestive medicine, obstetrics, and gynecology³⁻⁵. However, relatively few reports have described 3-D echoencephalography².

In this paper we examined the central nervous system in infants by using 3-D echoencephalography and evaluated its usefulness.

Methods

Three-dimensional echoencephalography was performed with a Medison (Seoul, Korea) model Voluson 530D with 3-5 MHz transducer. To obtain images, the transducer was placed on the anterior fontanel. During the examinations, the subjects were unsedated and lay quietly awakened. Coronal sections were serially and automatically scanned from the frontal to the occipital portions in a few seconds. Or sagittal sections were scanned from left to right (or vice versa). The angle of scanning was 60 degrees and 250 B-mode images were memorized. Five seconds were spent on the scanning.

At first, we saw simultaneously three basic sections (sagittal, coronal, and horizontal) and decided the region of interest (Fig. 1). 3-D images were constructed by an internal computer. One 3-D image was made in 0.3 seconds, and rotating animation was made in twelve seconds.

There were four different modes. By using the surface mode, we could get a cubic image. Maximum mode accentuates strong echoes so that hard structures are displayed, while minimum mode accentuates weak echoes so that tender structures are displayed. In X-ray mode, reconstruction was concentrated on bony structures.

Results

Case 1

A preterm male infant, whose gestational age was 36.6 weeks and whose birth weight was 2088 g, was neither acutely ill nor showed any evidence of congenital malformation. The examination was performed at 20 days of age when his weight was 2180 g.

We could see any sections of our own accord and confirm the position of a section based on the other two basic sections (Fig. 2).

Three-dimensional reconstruction using surface mode shows impressively vivid details of a cerebrum (Fig. 3).

The shape of a third ventricle could be seen by cutting low echoes in a surface mode (Fig. 4).

Figure 5 shows a posterior surface of the third ventricle. The surface from the third ventricle to a cerebral aqueduct can be observed.

Reprint request
Kou ICHIHASHI: Department of Pediatrics, Jichi Medical School, 3311-1 Minamikawachi, Kawachi-gun, Tochigi 329-0498, Japan
(Received December 14, 1998 ; Accepted March 1, 1999)
Fig. 1  Basic three-axle sections for 3-D imaging.
The region of interest was decided in three sections (A, B, C) and one 3-D image (D) was structured.

Case 2
The male patient was born at 24.4 weeks' gestation and the birth weight was 448 g. The examination was performed at 182 days of age when his weight was 2252 g. His cerebral ventricular system was moderately dilated.

We could observe the three-dimensional structure of cerebral ventricles and choroid plexus by using minimum mode and maximum mode, respectively (Figs. 6 and 7).
Fig. 3 3-D image of a normal cerebrum.
Ch: choroid plexus. LV: lateral ventricle. V3: third ventricle

Fig. 4 3-D image of a third ventricle.
A: cerebral aqueduct

Fig. 5 A posterior surface of the third ventricle.

Fig. 6 Lateral ventricles at minimum mode.

We scanned from the midline to the lateral portion and traced manually an area of the lateral ventricle in each sagittal section at intervals of 2.5 mm (Fig. 8). The areas were traced in 8 sections. An internal computer integrated them and measured the ventricular volume. The volume of the lateral ventricle in this case
Discussion

There is no more proper tool than the 3-D image to diagnose the three-dimensional human body. 3-D images from any position can be structured. By 3-D image, especially by using rotating 3-D animation, we can easily understand complicated 3-D construction of an organ.

Until the present, B-mode images had been limited by an approach only through an anterior fontanel. By using 3-D echoencephalography, we could get free B-mode images from any direction. We can also examine the coronal, sagittal, and horizontal planes simultaneously, detecting an object's position.

One of the usefulness of ultrasonography is to get a real-time image. However, it had taken a long time to reconstruct a 3-D image, which had been a weak point of 3-D ultrasonography. Besides, we can not understand 3-D construction of an organ only by one 3-D image, but we can understand it by rotating 3-D animation for the first time. Many 3-D images are needed to rotate the animation, which spends a long time.

In this study we could finish full scanning in five seconds and it took only 0.3 seconds to reconstruct one 3-D image. Therefore, we could examine conscious children and perform a re-examination when an image was not good. The weak point of 3-D ultrasonography is being improved now.

A lateral ventricle has a complicated feature. It dilates asymmetrically in an infant with post hemorrhagic hydrocephalus. Therefore, it is important to grasp the three-dimensional structure of cerebral ventricles and to measure the volume of the lateral ventricle. By using 3-D ultrasonography, these things are possible.

We concluded that 3-D echoencephalography in infants is useful for the following reasons: 1) It easily produces a three-dimensional structure of the central nervous system, especially the ventricles, 2) It allows images of any section, which in the past could not be scanned by conventional two-dimensional echoencephalography, and 3) It permits measurement of lateral ventricular volumes.
Acknowledgment

We are grateful to Mr. Naoyuki Aoki, Technical Section Manager, Medison Japan Co., Ltd., for his excellent technical work.

References


文献抄録

Estimation of Vessel Flow and Diameter during Cerebral Vasospasm
Using Transcranial Doppler Indices
Giller CA, Hatab MR, Giller AM

脳血流測定法としての transcranial Doppler ultrasonography (TCD) の欠点は、TCD から得られる血流速度が測定部位の血管径の変化により影響を受け、血管内血流量の定量的な変化を相関しないことにある。このことは、脳主幹動脈の血管径が減少し、その支配領域の脳血圧を惹き起す病態であるも脳出血や動脈狭窄症などにおいては、重要な問題となる。本研究は、通常の TCD の解析では用いられていない Doppler スペクトルの強度を解析し、血管内血流量と血管径を推定した。もし、本法が確立方 TCD のみで血管内血流量と血管径を定量的に知ることが出来ると、その意義は高くななるため本論文を紹介する。

【目的】TCD では、直接血流量や血管径が測定できないことから、脳血流量としての評価法としては大きな限界となっている。この限界を解決するため、血管内血流量に比例するとされる全 Doppler スペクトルの intensity-weighted mean から得られる指数を導入し、測定部位の血管径が一定である状態（過換気と低換気状態）と血管径が低下する状態（血管収縮）での変化を検討した。

【対象と方法】Flow index (FI) は、時間単位の Doppler スピートルの強度に関するデータを高速フーリエ変換した第一高調波から計算し数値のデータを加算平均し解析した。血管内血流量は、血管径と平均血流速より算出されることから、area index (AI) は FI を平均血流速で乗じたものとした。測定部位の血管径が一定の条件下での FI と AI を検査するため、20例において換気状態の変化により高 CO2 低 CO2 正常 CO2 状態にて評価した。さらに血管径が減少する病態での変化を評価するために、も脳出血患者において 2 回の異なった時期に TCD と血管撮影を行い、AI の変化を 23 血管の 41 の部位における血管撮影から得られる血管径と比較した。

【結果】健常例において、FI は平均値で相関した（r=0.97）が、AI の変化は 3%以下であった。AI の変化から、全血管において血管収縮から得られる血管断面積の変化を推測可能で、両者の相関は全データからも r=0.90 と高い相関が得られた。

【結論】Intensity-weighted mean から得られる指数により、CO2 の変化や脳血管収縮における血管径の変化を推測可能である。本研究により本法が脳主幹動脈における血管内血流量の正確な評価法として用いることが可能であると共に、も脳出血後の脳血管径の変化の推定法としての有用性を示している。

本研究は著者らも述べており、また comment で指摘されているように、本指標は血流が層流状態でのみ適用できるもので乱流により影響をうけること、Doppler 信号の強度を解析しているためターゲットの保持、入射角と部位、深度、gain、power、scale の設定により容易に変化を受けることなどがある。結論の欠点は、条件設定をかなり厳密にしないと再現性が得られないこと、測定値が絶対値として得られず、他の脳循環測定法など得られる定量的な数値との関連が明らかでないことも挙げられるであろう。何れにしても、今後臨床において広く使われるようになるためには、更なる検討が必要と思われる。

（京都武田病院 脳神経科学診療科 塩原敏之）