

# 八十八年度行政院國家科學委員會專題研究計畫成果報告

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立體於超音波的早期胎兒檢查於遺傳諮詢之應用

執行期限: 87 年 8 月 1 日 至 88 年 7 月 31 日

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## 一、中文摘要

立體超音波為新近發展之全新領域,可  
提供較傳統平面超音波其它許多不同的好  
處。本研究實行期間,重新檢視了立體超音  
波於各種染色體疾患及胎兒異常的超音波  
指標,從而大幅增進了以上疾病的診斷率;  
這些超音波指標主要包含了顛顏異常(含小  
耳症及下顎骨生成不良),骨骼四肢發育不  
良及外生殖器異常;這些超音波指標在傳統  
二維超音波容易忽略或判斷不易,因此立體  
超音波於此類胎兒先天疾患的輔助診斷是  
極其重要的。

三維血管攝影超音波亦是今日全新之技  
術,它可將血流以能量形式表現,而不是像  
傳統都卜勒彩色超音波的平均頻率轉移。因  
此技術是全新的,它在婦產科的經驗非常  
有限,目前全世界人仍無此方面報告。本計  
劃前瞻性的分析了胎兒血管系統及胎盤血  
管異常,驗證腫瘤之血管生成,我們的工作  
成果包括了正常型態的確立及異常血管的  
分類,大大提供了對異常胎兒生理或病態  
的確認或診斷,同時也提供了三維血管攝  
影超音波在這方面更多的應用。

## 二、英文摘要

Three-dimensional (3D) ultrasound is a  
new technique offering various possible  
advantages over conventional two-  
dimensional ultrasound. The simultaneous  
display of three-orthogonal planes helps to

obtained accurate sections and suitable views  
needed for accurate diagnosis, as well as  
geometric or volumetric diagnosis. Further-  
more, surface rendering gives detailed  
plastic images give a detailed plastic image of  
fetus, and transparent modes enable a three-  
dimensional display of fetal skeleton to be  
obtained. Echo CT also has the advantages of  
reducing radiation exposure, expense,  
movement artifact than conventional CT and  
MRI examinations.

Three-dimensional color power  
angiography is also a brand-new technique  
that may express blood flow by encoding the  
power in the Doppler signal rather than the  
mean Doppler frequency shift, as in standard  
color Doppler imaging. Because the technique  
is new, the experience in obstetrics and  
gynecology are limited. So far, there is no  
report of 3D CPA in the application in  
Obs/Gyn field. Possibly it may have  
contribution in evaluating fetal vascular  
system, placental anomalies and assessment  
of angiogenesis in genecologic neplasm. We  
warrant our future work could provide more  
answers of applications in the Obs/Gyn field  
of 3D CPA.

## 三、計劃緣由與目的

In 1993, Drs. Jonathan Rubin and Ronald  
Alder first reported a new Doppler  
sonographic technique that encodes the power  
rather than the mean frequency shift of the  
Doppler signals. This new technique of power

Doppler ultrasound, also known as color power angiography (CPA), color Doppler energy (CDE), or amplitude-mode color Doppler ultrasound, have been introduced to the clinical practice for several years. So far, over one hundred papers concerning the use of power Doppler in various clinical fields have been reported.

Power Doppler US is approximately 3 to 5 times more sensitive than conventional color Doppler. The background noise produced by the conventional color Doppler may obscure the target image by displaying random colors in different spatial and temporal phases. In contrast, the background noise produced by power Doppler is displayed in uniform color, and the signal-to-noise ratio is generally high. Therefore, an additional color gain of 10-15 dB is usually achieved in the power mode without overwhelming noise. The display of intensity in power mode is based on the area under the power spectral curve, which depends on the total scatters (red blood cells) in the sampled vessel. Thus power mode is nearly angle-independent for Doppler interrogation. The equipment required by power Doppler basically involves upgrading the software of the original color Doppler, therefore; an investment in new equipment will not be necessary. Although it is obvious that the power Doppler is superior to conventional color Doppler in several aspects, the applications of power Doppler in the field of obstetrics and gynecology are still limited.

#### 四、結果與討論

##### *Early pregnancy*

Development of the hemochorial plate is essential for embryo implantation and future development. Faulty formation of the hemochorial plate will result a wide spectrum of pregnancy complications, such as threaten abortion, missed abortion, blighted ovum and possibly pre-eclampsia. Therefore assessment of hemochorial plate is quite important for

obstetricians.

In terms of developing uteroplacental circulation, various terminology have been used to describe the phenomenon, including subtrophoblastic or retroplacental blood flow, peritrophoblastic blood flow, intervillous blood flow. The advent of transvaginal color Doppler ultrasound brought exciting details of the pelvis and provide an *in vivo* assessment of the early uteroplacental circulation. From our experiences, the blood flow signals within chorion frondosum can be detected as early as 6 weeks of gestation. With 3D reconstruction, we can demonstrate that the flow signals are derived from the transformed radial and spiral arteries. Although there is still a debate in the existence of intervillous circulation in the first trimester, Boyd and Hamilton successfully demonstrated the patency between intervillous space and spiral arteries by using Indian ink percolation in 8 to 10-week uteruses. Our 3D power Doppler finding can be as an adjunct in the confirmation of the classic anatomy findings *in vivo* and help to elucidate the mystery of intervillous circulation before 12 weeks' gestation.

The role of transvaginal color Doppler ultrasound may refine the diagnosis of ectopic pregnancy. Prospective studies demonstrated that transvaginal color Doppler ultrasound considerably augmented the diagnostic sensitivity from 62% (gray-scale only) to 82% (with color Doppler mapping). With color flow mapping, demonstration of typical peritrophoblastic flow (known as "ring-of-fire" appearance) in the extraovarian mass can almost establish the diagnosis of ectopic pregnancy. 3D power Doppler is more sensitive and the 3D-rendered images can avoid plane-sample bias. Therefore it can significantly increase the detection rate of peritrophoblastic flow and thus substantially aid in the diagnosis of ectopic pregnancy (Fig. 7). We suggested that 3D power Doppler is a promising tool to investigate peritrophoblastic flow and add substantially in the diagnosis of

ectopic pregnancy.

#### *Placenta and umbilical vasculature*

The placenta is a vital, highly vascular organ which nourishes the fetus and exchanges waste between fetal and maternal circulation (Fig. 8). Various pathologies can occur in the placenta. Dr. Pretorius and her associates first used 3D power Doppler to visualize the overlapping fetal and placental vessels in the placenta.<sup>14</sup> She concluded that volume-rendered vascular images of placenta are valuable in augmenting the comprehension of placental anatomy, therefore have the potential in the detection of vascular disease which affect the placenta. These diseases may include arterial and venous thrombosis, villous infarction, placental insufficiency and twin transfusion syndrome. We also use 3D power Doppler US to investigate the umbilical cord in normal and abnormal conditions. From our limited experience, 3D power Doppler US provides more comprehensive details that can significantly assist in the diagnosis of various pathology of umbilical cord.

#### *Fetal circulation*

The umbilical cord contains one umbilical vein and two umbilical arteries. The umbilical vein enters the fetal abdomen in a craniodorsal course and connects with left portal vein. The left portal vein, together with hepatic veins, flows into inferior vena cava and finally drains into the right atrium. The blood returning from placenta is then pumped into left heart and further divided into descending aorta and intracranial circulation. Part of blood flow from the descending aorta drains into hypogastric arteries, and then to umbilical arteries. From our experiences, these overlapping fetal vasculature can be easily visualized and stereo reviewed on the monitor by using 3D power Doppler US. The fetal brain circulation can also be visualized by using this technique successfully. These comprehensive findings are helpful to

correlate the embryo circulation *in vivo*, and study the aberrant development of fetal circulation, such in fetal heterotaxy syndrome.

### 五、計劃成果自評

本計劃於期限內完成,而且計劃內容相關成果已在國際著名醫學期刊發表(見下參考文獻),且大多數為學門分科 SCI 在前 25% 者,成果可謂豐碩。尤其三維能量超音波在婦產科的應用的發表仍然很少,而由本計劃衍生的三維能量超音波論文將實質影響以後在婦產科臨床的應用。部份由本計劃衍生的論文將陸續於國際著名醫學期刊發表。

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