Original Article

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The Foetal 'Mind' as a Reflection of its Inner Self: Evidence from Colour Doppler Ultrasound of Foetal MCA

Sushil Ghanshyam Kachewar, Siddappa Gurubalappa Gandage

ABSTRACT

The unborn healthy foetus is looked upon as a blessing by one and all. A plethora of thoughts arise in the brains of expectant parents. But what goes on in the brain of the yet unborn still remains a mystery. 'Foetal mind' is a reflection of functions of its organs of sense, an instrument of knowledge that may even be reduced to machine to demonstrate the effect of sense organs and brain contact. Testimony to this fact are the various waveform patterns obtained non-invasively from the foetal Middle Cerebral Artery (MCA) by using Colour Doppler Ultrasound. Our study, conducted for evaluating the foetal MCA in a rural obstetric population in Maharashtra, India, explains how the MCA - a major artery supplying foetal brain, can give abundant information about foetal heart and foetal stress. When only the foetal heart is stressed by the presence of arrhythmias or ectopic beats, these changes are manifest in the foetal MCA velocity waveform pattern as seen on Colour Doppler study. When the entire foetus is under stress, as in cases of intra uterine growth retardation (IUGR), changes again manifest in the foetal MCA velocity waveform pattern and are designated as the foetal Brain Sparing Effect. Thus scientific evaluation of foetal MCA waveform can objectively demonstrate that the overtly non-communicating foetal brain indeed remains an internal organ of sense and a vital instrument of knowledge to clarify the various effects of sense organs and brain contact. Although the brain parenchyma or cerebral metabolism has not been studied here, cerebral vessels serve as a window to cerebral metabolism, as auto regulatory function of brain leads to changes in haemodynamics of cerebral vessels. Also, like other vessels,

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MCA mirrors foetal distress and IUGR; but unlike other vessels, e.g. the umbilical or uterine artery, which show these changes in the form of reduction or even reversal of diastolic flow, MCA shows an increase in diastolic component due to brain sparing effect. The unique connection between physical changes in the foetal heart, brain and mental operations are thus critically clarified to some extent, and this helps untangle and comprehend the lattice of mental operations. Although this preliminary study has its limitations, it still carries forward the present corpus of knowledge on the strength of its evidential and critical enquiry and helps unravel the concept of foetal consciousness.

Key Words: *Brain; Colour Doppler ultrasound; Foetal distress; Foetal mind; Foetus; IUGR; KG waveform; Middle cerebral artery; Mind, pravara effect; Velocity waveforme*

Introduction

Most people, especially in cases where pregnancy is welcome, look upon the foetus as a blessing, and it is generally believed that this foetus harbours a beautiful 'mind', which is actually a reflection of its evolving brain.

The human brain is capable of everything. It is the anatomical site of the 'mind'. To be functionally active, this brain should receive adequate oxygen and nutrition. The foetal Middle Cerebral Artery (MCA) supplies almost 80% of the blood to the foetal brain. Imaging evaluation of this vessel is therefore indicative of stress to either foetal heart or to the entire foetus.

In addition, the peak of the systolic component of the velocity waveform (PSV**)** that can be calculated from these waveforms is used to screen for foetal anemia as it has been proved that increased MCA-PSV above 1.5 times multiple of median (MoM) indicates moderate to severe foetal anaemia (Nardozza *et al.*, 2007[15], Kurmanavicius *et al.*, 2001[10], Mari *et al.*, 2000[14], Hernandez-Andrade *et al.*, 2004[8]).

In the course of our scientific study on non-invasive assessment of foetal MCA-PSV using Colour Doppler ultrasound, we came across a number of different patterns of foetal MCA velocity waveforms which conclusively demonstrate foetal 'mind' is a reflection of functions of its organs of sense, and this 'mind' is thus an instrument of knowledge that can be reduced to machine to demonstrate the effect of sense organs and brain contact.

Materials and Methods

The study was conducted at the Ultrasound Unit of the Rural Medical College, Pravara Institute of Medical Sciences at Loni in Ahmednagar [Maharashtra, India], after obtaining prior permission from the University

Research Cell and its Ethics Committee. Informed written consent was obtained from each pregnant lady before her obstetric ultrasound scan, and Colour Doppler evaluation of foetal MCA was performed. A total of 1100 pregnant females were evaluated from June 2010 to August 2011. Participants in whom a satisfactory waveform could not be obtained due to excessive foetal movements were excluded from this study.

The author (SGK) who conducted this study has more than eight years experience in ultrasound recorded velocity waveform of foetal MCA using Siemens G-60 Doppler ultrasound machine. During this examination, the pregnant lady lay supine on the bed and at ease. Then a 3.5 MHz curvilinear transducer was used to obtain a transverse section of the foetal head, first on grey scale imaging. Then, using colour flow imaging function, foetal MCA was localised near the circle of Willis. The proximal MCA was then sampled just after its origin from the internal carotid arteries by using pulse Doppler, such that the angle of insonation was zero degrees. The image was frozen only after obtaining a steady waveform pattern. The entire process took around 5-15 minutes.

The various patterns of foetal MCA velocity waveforms were then compiled and evaluated.

Results

In our study we observed that the following four broad heads were useful for describing the MCA waveform changes that could enlighten us about the status of the foetal brain and 'mind':

- A normal healthy foetus had moderately tall well-defined foetal MCA velocity waveforms with a systolic component and a diastolic component [Figure 1]. The pattern was uniform and without any bizarre peaks in between. Normally the diastolic component of the velocity waveform was less than one third the height of the systolic component of the velocity waveform.
- When only the foetal heart was under stress, as in cases of foetal ectopic beats or foetal cardiac arrhythmia, this normal uniform waveform pattern was lost, and in its place, aberrant and bizarre waves presented themselves amidst the normal pattern [Figure 2], therefore bringing in chaos.
- When the entire foetus was under stress, as in cases of Intra Uterine Growth Retardation (IUGR), the diastolic component of the waveform pattern became half, or more than half, as tall as the height of the systolic component [Figure 3].
- When the foetus was severly anaemic, the MCA-PSV rose and became more than 1.5 times MoM for that gestational age [Figure 4], thereby indicating foetal stress due to reduced oxygenation.

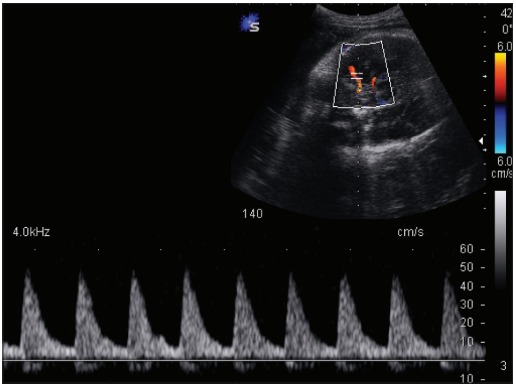

Figure 1: MCA waveform in a normal foetus.

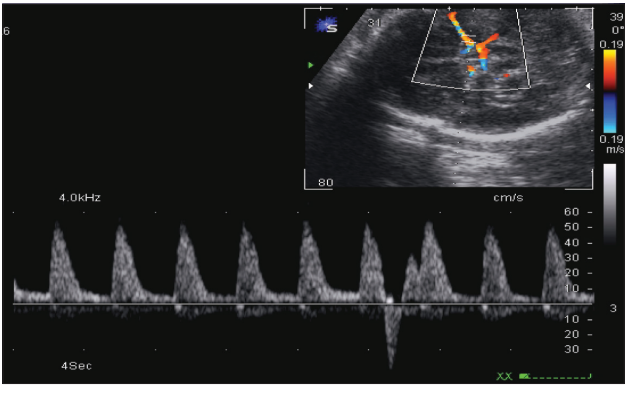

Figure 2: MCA waveform in a foetus with ectopic beats.

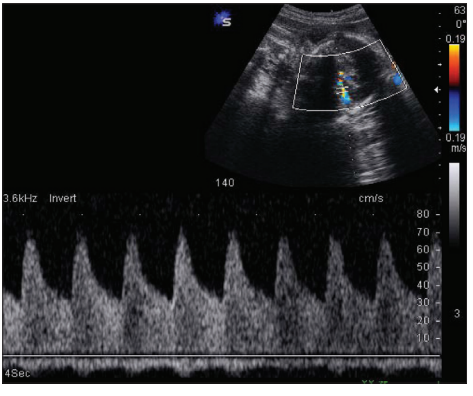

Figure 3: MCA waveform in a fetus with IUGR (Brain Sparing Effect).

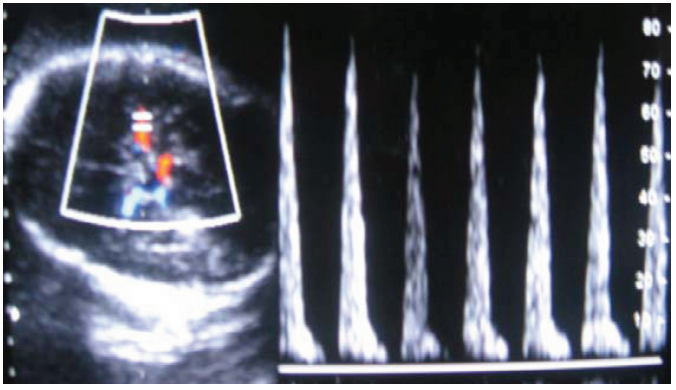

Figure 4: MCA waveform in a foetus with severe anaemia showing elevated PSV.

Discussion

Relevant literature proves it beyond doubt that brain is the structural correlate of mind, and mind the functional correlate of brain (Singh and Singh, 2011[19]). Furthermore, to effectively understand human experience, the triad of external environment, internal environment and consciousness are vital (Ibid[19]). Adult, and therefore even the foetal, brain is the centre for all thoughts, emotions, will and actions as it executes orders to the different systems of body on receiving perceptions from its inner as well as outer environment. Such orders issued by foetal brain in response to different stimuli from its inner or outer environment, and to its circulatory system, would therefore be manifested in the foetal MCA which is the major blood vessel supplying the brain. Hence, we believe that evaluating changes in foetal MCA would be interesting and might even open up the much-awaited window to the world of the foetus and help demystify foetal brain functions and foetal consciousness.

Other reason to choose foetal MCA rather than other foetal vessels is that cerebral auto regulation causes hemodynamic changes in the MCA (Hanif *et al.,* 2007[7]). It is also the vessel of choice for assessment because it is accessible and sensitive to the effects of hypoxia (Brennand, 2009[2]). Apart from having lowest intra- and interobserver variabilities, the advantage of studying the MCA is that it is easy to get an angle of zero degrees between the ultrasound beam and the direction of blood flow, thereby enabling correct assessment of the velocity (Mari, 2005[12]).

As per the brain process theory (Singh and Singh, 2011[19]), it is possible for a functional output to exist even after the structure that produced it no longer exists. A product outlives the 'machine' that produced it (Ibid[19]). Therefore,

proper documentation and scientific analysis of foetal MCA velocity waveforms from different foetuses would help in unravelling the mysteries of what goes on in the foetal brain that is manifested as collective functions labelled as the foetal 'mind', and expressed as its consciousness.

Foetal 'mind' is a collection of brain functions and its heart is an organ of blood circulation. Complete knowledge and understanding of both these, especially in a foetus, still remains elusive. Evaluating MCA waveforms can objectively throw some light on the status of both these, because MCA waveforms are affected by changes in both. This article discusses and attempts to prove how to bring this in objectivity.

As mentioned in our results, MCA waveform in normal foetuses is seen as a uniform pattern with a tall systolic component and a diastolic component that is less than one third the height of systolic component, without any aberrant waveforms in between.

Ectopic beats or cardiac arrhythmias put a lot of stress on the foetal heart thereby disturbing the rate as well as rhythm of the normal pulse. This disturbed pattern is transmitted via the aorta and carotid arteries to the foetal middle cerebral arteries, and is manifested in the form of aberrant or bizarre waves disturbing the normal uniform waveform pattern. Study of relevant literature shows that till date no researcher has demonstrated and documented this type of foetal middle cerebral artery waveform pattern. As this effect (Cardiac ectopics and arrhythmias manifesting as disturbances in foetal MCA waveform) is first documented successfully in this institute we would like to label it as the *'Pravara Effect'*; and the changed foetal MCA waveform pattern as the *'KG waveform'* [KG-after Kachewar-Gandage; the researchers in this project]**.** Such eponymous naming is permissible, and in the better tradition of scientific naming (Singh, 2011[17]).

Cardiac arrhythmia in a foetus causes extra systolic beats which are unsynchronised in 85% of cases, but are supposed to cause no severe clinical problem in almost 95% of them (Kleinman et al., 1985[9]; Copel and Kleinman, 1986[3]). Newer insights, however, have led to the understanding that ectopic beats, once thought to be entirely benign, do have important pathologic associations (Strasburger and Wakai, 2010[22]; Maeno *et al.,* 2009[11]). Earlier studies showed that about 1% of normal foetuses, and 1 - 2% of patients with structural heart defects, showed these extra systoles (Stewart and Wladimiroff, 1988[20]; Van der Mooren et al., 1992[23]). Recent studies show that about 0.5% of foetuses with simple ectopy, and 6% of foetuses with complex ectopy, develop supraventricular tachycardia (Strasburger *et al.,* 2007[21]) while still in utero, and this increased risk might as well extend into the neonatal period (Strasburger and Wakai, 2010[22]).

Normally the diastolic component of the velocity waveform is less than one third the height of its systolic component. When the height of this diastolic component becomes half, or more than half, the height of the systolic component, foetal Brain Sparing Effect is said to have occurred. This happens when the foetus is hypoxic, and is due to preferential shunting of blood to the foetal brain due to splanchnic vasoconstriction and cerebral vasodilatation, thereby resulting in an increased forward component to the waveform in diastole (Kleinman *et al.*, 1985[9]; Copel and Kleinman, 1986[3]; Vyas *et al.*, 1990[24]; Mari and Deter, 1992[13]). Of the various diagnostic indices proposed to evaluate the effects of stress factors from inner as well as external environment on the vulnerable developing foetal brain, this non-invasive Doppler method seems to be consistent and effective (Giussani, 2011[6]; Antonow-Schlorke *et al.*, 2011[1]; Franzin *et al.*, 2010[5]).

Measuring the peak of the systolic velocity of foetal MCA waveform (MCA-PSV) is a widely accepted, simple and efficient non-invasive method of foetal haemoglobin estimation. In anaemic foetuses the peak systolic velocity increases because of the lowered viscosity of anaemic blood. So the increased cardiac output results in raised peak velocity when the foetal haemoglobin is reduced (Nardozza *et al.,* 2008[15]; Fan *et al.,* 1980[4]). Hence, it is important, not only to look at the waveform pattern that we get from the foetus on Colour Doppler, but also assess the peak of systolic velocity, and compare it with reference range at that gestational age, because increase in this MCA-PSV beyond 1.5 times MoM is indicative of foetal anaemia. Thus, a mere look at the pattern of waveform can assist in making a non-invasive diagnosis so as to facilitate appropriate management. Moreover, the system stands true even when no clinical history is available, or is inadequate, or even when the pregnant lady and/or her relatives are not in a position or condition to give history.

The strength of the present study is that it is population based. It is not merely conceptual but is scientifically evidenced, as it objectively demonstrates the unique connection between physical changes in the foetal heart, brain and mental operations. Thus it helps untangle and comprehend the lattice of mental operations (Singh and Singh, 2011[19]) by offering one objective lead. This study carries forward the present corpus of knowledge on the strength of its evidential and critical enquiry and helps take a step forward in unravelling the concept of 'foetal consciousness'. Moreover, the study is replicable and non-invasive.

The *Pravara effect* and the *K-G waveform* proposed in this study need replication and/or correction/refutation from other researchers internationally -- since replication, correction and refutation are the three major methods of scientific progress (Singh and Singh, 2003[18]; Singh 2010[16]).

Concluding Remarks [See also Figure 5: Flowchart of Paper]

'Mind' is a mystery and foetal 'mind' is the deepest of these mysteries, as the foetus cannot communicate with us in ways an adult, or even the living, can. Nevertheless, the foetal 'mind' - a collection of its brain functions - continues to be a reflection of its inner self. This can be objectively demonstrated by Colour Doppler ultrasound evaluation of waveform patterns of the Middle Cerebral Artery of the foetal brain.

The normal waveform pattern, which has a regular systolic and diastolic component, is seen in states of complete foetal health. But when the foetal inner self is traumatized by cardiac ectopics or arrhythmias, bizarre and aberrant patterns (*KG waves*) are seen to replace normal waveform due to the *Pravara effect*. When the entire foetus is affected in conditions of intra uterine growth retardation, the Brain Sparing Effect sets in. In cases of foetal hypoxia due to anaemia the peak of the systolic velocity of the waveform rises.

To conclusively prove that the foetal 'mind', a collection of its brain functions, is a reflection of its inner self and an instrument of knowledge, one must rely on objective rather than subjective methods. Only after understanding the connection between physical changes in the brain and mental operations, can one attempt to untangle and comprehend the lattice of mental operations (Singh and Singh, 2011). This is all the more important in the case of a foetus whose methods of communication with us are limited.

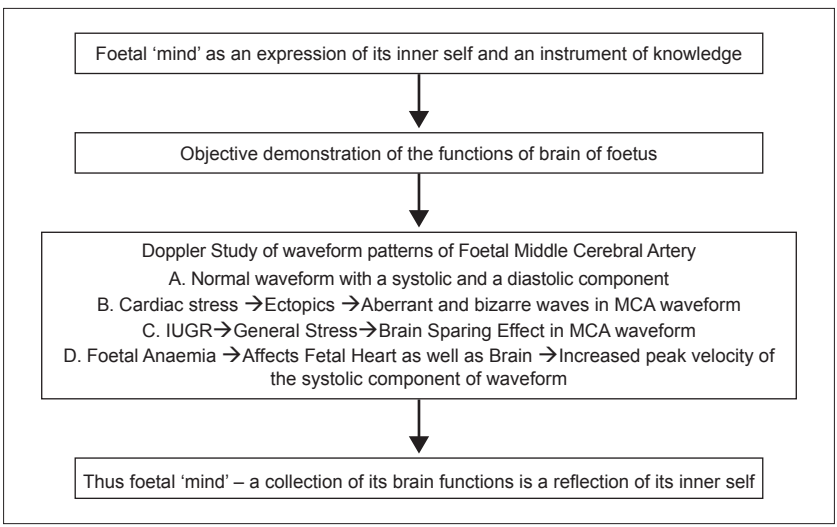

Figure 5: Flowchart of paper

Study of waveform of the middle cerebral artery of the foetus on Colour Doppler ultrasound holds promise to solve a part of this mystery. Earnest attempts to establish this linkage and further scientific investigation on this relatively untrodden path promise to add significantly to the present research corpus, and also set the agenda for present and future research trends, so as to enable not only the foetus but also patients in coma or in terminal phases of Alzheimer's to express themselves, and for us to comprehend them.

Take home message

Our study on Colour Doppler ultrasound of foetal MCA shows that it is a non- invasive key to unlock the foetal 'Mind' and demonstrate the reflection of its inner self. The changes occurring in the pattern as well as the peak of systolic velocities objectively demonstrate foetal stress and establish cause-effect relationship. Serial follow up enables monitoring progression or regression. The method is easy, replicable, cost effective; with minimal inter or intra observer variability, and entirely harmless for the mother as well as the foetus.

Conflict of interest

None declared

Declaration

This is our original unpublished work not under consideration for publication elsewhere.

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To all the pregnant ladies and their foetuses that were kind enough to allow us this experience for the benefit of mankind.

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Questions that this Paper Raises

1. Is human 'mind' – a collection of its brain functions - really a reflection of its inner self, and an instrument of knowledge?

2. If yes, does this apply to the foetus as well?

3. If yes, what are the methods of proving this objectively?

4. Are we doing enough to realise that the foetus has a 'mind' of its own?

5. Can the current 'mind-body' concept of adults be applied to the foetus as well?

6. Will further work on MCA by Colour Doppler yield newer insights into human 'mind' in subjects who cannot normally communicate e.g. those declared brain dead/comatose, those on ventilators, or those with special needs e.g. deaf, dumb and mute, and patients with Alzheimer's disease, or other dementias? Would such studies broaden the 'Pravara Effect' and add new 'KG waveforms'?

7. Would Colour Doppler of MCA yield newer 'KG waveforms' and add new dimensions to the 'Pravara Effect' in twins, triplets and multiple pregnancies?

About the Author

Sushil Ghanshyam Kachewar is a Radiologist by profession. He completed his MD and DNB in Radio-diagnosis and is currently pursuing PhD in the Medical faculty on the Topic, 'A prospective cross sectional study of fetal middle cerebral artery peak systolic velocity in normal obstetric population attending Rural Medical College, Loni'. At present he is working as a full time Associate Professor in the Radio-diagnosis Department of Rural Medical College, Pravara Institute of Medical Sciences (DU), LONI. He has published about a dozen scientific articles and about half a dozen books pertaining to his speciality. His current area of research is the non-invasive evaluation of the middle cerebral artery of foetus by Colour Doppler ultrasound imaging. He is a life member of Indian Radiological Imaging Association, Indian College of Radiology and the Indian Red Cross.

About the Author

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