Prediction of Autism Antenatally via Fetal Ultrasound and Postnatally via MRI Studies

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Abstract

Background: ASD is a developmental disability which is characterized by difficulties in social interaction and communication, and which impacts behaviours in individuals with the condition, with worldwide incidence rate rising. Very little seems to be known about techniques for early identification of children at risk for developmental delays: IDEA requires early identification for a program to be included under the act, yet current diagnostic tools seem to rely primarily on behaviourally based instruments that are generally implemented after the child is two years of age. This has created new openings in the ability to detect biomarkers for ASD at an early stage before showing the behavioural signs.

Aim: The overall goal of this research will be to determine the feasibility of identifying antenatal ASD using fetal ultrasound as well as postnatal ASD using MRI scans in an effort to understand the developmental brain markers associated with increased risk of autism.

Methods: A prospective cohort study was conducted using pregnant women who agreed to participate in the study and consent to have their routine ultrasound examination as well as their offspring after birth. Neonatal brain structure and development was evaluated with 3D/4D ultrasound was in terms of head circumference, corpus callosum and ventricles. Six and 12 month follow-up MRI scans were used to identify structural and functional brain abnormalities with shortened amygdala and decreased frontal cortical volume. Prediction studies were used

to evaluate the effectiveness of the imaging markers by means of statistical tests and machine learning algorithms.

Results: Prenatal ultrasound examination showed that children with eventual ASD have an increased head circumference and reduced corpus callosum thickness whereas MRI investigation performed after birth showed that children with ASD have enlarged amygdala and decreased volume of the frontal cortex. The efficacy of using antenatal ultrasound in predicting the outcome was 70% while using postnatal MRI the efficacy rose to 85%. When both the methods were used the accuracy in predictions increased to 90%.

Conclusion: Firstly, fetal ultrasound and postnatal MRI can both be considered to have a high feasibility to be used in early diagnosis of ASD. The use of these imaging technologies in early screening programs is likely to enhance early diagnosis and hence the treatment of children with autism improving their prognosis.

Keywords: ASD, prenatal screening, fetal ultrasound, postnatal MRI, early diagnosis, neurodevelopment in children, brain imaging, biomarkers for risk prediction

Introduction

ASD is a developmental disorder which affects social interaction, communication, and pattern of behaviours and interests. An ASD impact is seen in both the boy and girls of all ages and all ethnic backgrounds, despite having an estimated global occurrence of 1 percent of population of children currently, globally, this varies with regional and cultural difference in diagnostic approach and epidemiological consciousness. This becomes a spectrum disorder that presents in different ways from those who have extreme difficulties in communication and daily living to people who may have the slightest of symptoms besides which they live their lives without much help. However, it is important to note that, while diverse, ASD entails life-long consequences for the affected individuals and their families who may need significant support throughout the person's lifetime in the form of education, therapy and behavioural management techniques [1].

It is befitting to note that the effects of ASD transcend the individual level depending on the family and community in which the affected persons live. There are always parental/caregiver feelings of stress, social and financial cost when they are seeking a care and an intervention for a child. Further, society incurs certain costs from a financial perspective for example in the realm of health care, education, and social services to children with autism. Some of the difficulties can effectively be reduced through early detection and intervention with this necessarily making it important to diagnose ASD as early as possible [2].

ASD diagnosis has been done based on observation and tests which are usually administered when the child is between 18-36 months of age. This delay in diagnosis is as a result of using gross developmental milestones such as language development, and social skills. Some children with ASD may show sign such as poor speech development, lack of eye contact, and they may repeat some behaviours, leading the parents together with paediatricians to seek for developmental specialists [3].

Nonetheless, behavioural observation in diagnosing autism offers some difficulties especially in the initial stages of assessment since early symptoms of ASD are difficult to detect and may show a lot of divergence from one child to another. Third, subtypes of behavioural assessment are predicated upon clinicians' experience and the timing of parents' notification. Therefore, the majority of kids, especially those who experience relatively mild signs, remain undiagnosed during the childhood. This diagnostic delay will only allow children limited access to early intervention services which are known to have a positive impact on children's development.

It has been suggested that the process of early intervention is very helpful for language, cognitive and social development in children with ASD. Research shows that early developmental disorders can be managed better before the age of three because as it is known, the young brain has a higher level of susceptibility that can lesson the impact of the disorder in the long run, given that interventions are

made at this age. This underlines the need to search for more accurate and less bias ways of diagnosing ASD at the earliest possible stage. Hence, there has been a shift in the diagnosis methods that are not characteristics based and researchers have been inclining towards the utilization of imaging in diagnosis [4].

It is therefore important to get an early diagnosis and begin the intervention process to children with ASD as early as possible. This enables the intervention with therapies that address the root causes of autism prior to age of three years through speech and occupational therapy, behaviour modifications and social skills development. These interventions do help in a considerable manner in enhancing the developmental gains for children, which will enhance their level of independence and social interactions.

Another reason why it is important that early intervention is carried out is due to the fact that neural plasticity is most distinguished in childhood, particularly the initial years of the child's life. This is the time of life when the brain is very plasticised and very much receptive to any influence from outside and therefore considered the right time for therapy. The specific teaching and learning approaches that hold a lot of promise for children during this period of development remain effective in enhancing the language, communication and social interaction of kids at such age and the development of those with disability might enable them to reach the expected developmental milestones of children who are normally developed [5].

Similarly, the same investigations present definite shortcomings due to their focus on behavioural milestones and the generally imprecise and subjective nature of timing of behaviours in ASD children. For instance, some kids may not show clear signs of Autism during early ages and this makes it extremely hard for doctors to diagnose the issue or even provide the necessary support. To overcome these challenges, investigators are apparently shifting their focus to baseline measures which can be obtained using imaging techniques bearing evidence of scientific credibility in offering quantitative data on the development of human brain even before signs of behavioural changes surface.

Operant test, this includes Autism Diagnostic Observation Schedule (ADOS) and Autism Diagnostic Interview-Revised (ADI-R) are used in diagnosing ASD. These assessments are more of organized observation of the child's behaviour and speech, as well as interview with the parents regarding developmental history. Although these instruments are helpful in the screening of autism, these full tests are administered when a child manifests signs of developmental delays or atypical behaviour that is usually not apparent until the second or third year of life [6].

In comparison with this, fetal ultrasound with the following postnatal MRI option enable a possibility of revealing structural and functional changes in the brain that may be related with the development of ASD long before behavioural patterns occur. These techniques enable researchers to study the development of the brain to determine if the child in question has autism or not, and this is earlier as compared to the marked symptoms of the disease and is less subjective in nature.

One of the prenatal diagnostic tests that are widely used during prenatal checkups is fetal ultrasound can give important clues as to the state of the development of the fetal brain. With the help of the improvements in the ultrasound equipment, like 3D and 4D US, researchers can now see a fatuus's brain structures, like the corpus callosum, the ventricles and cortical development in utero. Some studies have also commenced research into whether some distortions in these structures may be used as predictors of early ASD.

Another possibility with more information for early diagnosis of ASD is postnatal MRI examinations made in infants and young children. MRI scans can capture the details of the brain diffusion and connectivity and thus the variations of the structural and functional aspects of the brain in children with ASD compared to those who do not have ASD. For instance, it has been discovered that children with autism display variations in size and coherence of the structures of the brain that are responsible for social functioning such as the amygdala and the frontal cortex [7].

There has been increasing concern on the ability to detect autism based on imaging techniques before any behavioural signs are observed in the children. Fetal ultrasound and postnatal MRI scans are two of the most prospective modalities for this purpose. These techniques may significantly affect ways of autism diagnosis as they offer quantifiable information on brain development and therefore can help to identify children at higher risk of developing ASD earlier.

Fetal ultrasound is a normal, non-invasive useful tool that is used generally during pregnancy in order to evaluate the growth of the fetus. Currently, there are sophisticated machines in ultrasound that allow differentiations and definition of almost every organ including the fetal brain thus aiding researchers in comparing patterns and growth of the brains of fetuses that may be vulnerable to developing autism. For instance, other research has established that smaller or asymmetrical corpus callosum which is a region between the two halves of the brain might contribute to the development of the disorder.

Postnatal MRI, performed on infants and young children, is the additional source for investigation of early brain development in relation to autism. MRI reveals in detail structural and functional characteristics of the human brain and makes it possible to reveal in children with and without autism differences in the intensity of cytokines and cytokine receptors. For example, children with ASD demonstrate structural changes in the packing of social processing components part of the amygdala, hippocampus and frontal cortex [8].

This article is going to discuss whether fetal ultrasound along with postnatal MRI can help identify the autism spectrum disorder. In this research, the goal of investigating brain development prenatally and during the initial years of life is to find out whether imaging markers at birth can be used to predict children at risk of developing ASD to facilitate timely diagnosis and intervention. Finally, the overall enhancing of the situation and increasing of success levels at the earlier stage of children with autism can be a goal of using all the mentioned forms of therapies and support.

Thus, the combination of fetal ultrasound and postnatal MRI into diagnostic algorithm of ASD appears to be a new perspective in early ASD diagnosis. As it is apparent in the rapid development of imaging techniques, medical experts may soon be able to identify autism in children in particular and diagnose the condition in a more accurate manner thus enhance the quality of their lives as well as their families.

Material and Methods

This investigation was intended as a prospective cohort trial for the purpose of assessing whether it is possible to diagnose ASD during pregnancy based on fetal ultrasound or after the child's birth with the help of MRI imaging. The choice was made to use a prospective design because this made it possible for the researchers to study the development of the brain across a number of periods, including the prenatal period as well as infancy and early childhood. It also made it possible that the data got from the imaging studies was directly matched with the later development of ASD from the children's developmental progress.

Participants in the cohort for the study were pregnant women who were receiving usual prenatal care in a network of affiliated hospitals/clinics. Some of these mothers were followed up to the time of delivery while their children were observed after birth. The work included fetal brain ultrasound scan during pregnancy and MRI scan after the birth of a child. It was, therefore, the final analysis to identify if one could diagnose a future ASD by evaluating the presence of presumed brain developmental markers seen through these imaging techniques [9].

To achieve homogenous sample and to rule out other factors, purposive sampling was used with specific inclusion & exclusion criteria. The inclusion criteria involved three groups of pregnant women receiving routine antenatal care and this included Pregnant women in their second trimester that were between 20 to 28 weeks of pregnancy at the time of recruitment. Singleton pregnancies only were recruited to the study so as to exclude effects of multiple births on brain development. Every mother signed the consent for the study and for her child to be further followed postnatally through imaging and developmental assessment.

These subjects were excluded from the study if they had come to the attention of the clinic with any known disease that could independently influence fetal or infant brain development including infections, teratogenic exposure or a positive screen for genetic disorders on the routine screening tests offered during pregnancy. The participants were also screened out for neurological disorders, psychiatric disorders or conditions that may affect the brain, and women with family history of autism to eliminate genetic influence on the results. In addition, any pregnancy complications including preeclampsia or gestational diabetes or intrauterine growth restriction were excluded because such fetal factors that affect the development of the fetal brain. During infancy, the children were also excluded if they were born preterm or if they had complications such as hypoxia or low birth weight during birth since these would distort the results of predicting ASD.

The fetal ultrasound imaging was done using 3D and 4D ultrasound imaging techniques that provided clear image of developing fetal brain. Ultrasonic scan was done at the mid-second trimester at 20-24 weeks and at early third trimester at 28-32 weeks. This timing was considered to record significant events in brain construction at certain phases of brain construction that are characterized by increased growth of parts of the brain that deal with social and cognitive performances.

This was done with the help of high end USS white scrude ultrasound that can perform 3D/4D imaging. Thanks to these technologies the researchers were able to map the shape, size and location of major structures of the human fetal brain. Scans were taken by a trained sonographer while all the measurements were done by a radiologist with a special interest in fetal brain imaging.

Several brain structures were included as indices for this study because of their previously documented involvement in ASD. Key measurements included:

Head circumference: The gestational age, ultrasounds of fetal abdomen are typically done at gestational age and have been associated with neurodevelopmental outcomes. Studies that have been conducted in the past indicate that children with ASD may have an unusual increase in head size with some having bigger head sizes in their fetal development [10].

Brain development markers: Hence, specific areas of the brains were gauged such as: the corpus callosum; the ventricles; and the cortical plates. Expectedly, the fibbers passing through the major tracts of the corpus callosum linking both the two brain hemispheres were of analytical interest especially in social cognition and communication. Anatomical atypias of the size and / or the shape of the corpus callosum has been claimed in ASD. In addition to all that, the end chambers known as ventricles, through which circulates the cerebrospinal fluid, were measured with the aim of evaluating if there was any additional growth or development that was abnormal to determine the development of the brain. Another marker used in evaluating the maturational of the fetal brain was the cortical plate, a structure which plays an important role during development that is associated with the formation of cortical layers.

Ultrasound scans were conducted twice during pregnancy: Maternal weight gain should be encouraged; this can be done through where the woman puts on weight at least once in the second trimester (20-24 weeks) and once in the third trimester (28-32 weeks). These time points were selected based on the major developmental processes of the brain which occurs when basic mental units and structures of the brain are rapidly developing. The scans were planned and conducted in such a way that these dynamic processes were captured for those key developmental periods, to give a snapshot of fetal brain growth.

In several studies, babies were taken through MRI scans soon after they were born to analyse their brains' development and integration. MRI was selected because it would enable the researchers to obtain fully resolved images of the brains' structures and also allow for explorations of structural and functional development of the brain in a specific age group. The postnatal MRI was performed twice: They are administered only once at 6 months of age and another one at 12 months of the child's age. These early life periods were chosen due to the fact that they correspond with the brain development and appearance of behaviours related to social and cognitive development which are affected by ASD.

Structural MRI and functional MRI that is fMRI were applied to reveal different aspects of developmental processes. Structural MRI was used to quantify the brain structure through measurement of the volume and thickness of the sections while fMRI was used to measure the activity and connectivity of the brain especially in the social communication region and sensory [11].

To this end, important and known areas of the brain linked to children with ASD were the main area of focus in the MRI studies. These included:

Amygdala: A part of the brain that helps to facilitate interpretation of both moods and social signals. Atrophy of the amygdala or hypertrophy along with the accompanying dysfunction has been closely associated with the ASD.

Frontal cortex: A well known structure associated with decision making, planning as well as social conduct. Abnormality in the structure and function of the frontal cortex has been blamed in the occurrence of ASD.

Corpus callosum: Before moving further, it is worth remembering what was said in the antenatal ultrasound section: corpus callosum plays a vital role in connecting two halves of the brain. Therefore, postnatal MRI was utilized to study further this structure in order to determine any changes in the development that might occur after birth.

The quantitative method for the current study involved statistical methods of data analysis in addition to the machine learning algorithms to determine the value of the imaging findings in the prognosis of the patients.

To establish whether the results of the current study correlate with a later ASD diagnosis, investigators utilized regression analysis to determine whether the size and development of certain regions of the brain predicted an ASD at 2- 3 years of age. Additional Receiver Operating Characteristic (ROC) curves were constructed in order to examine the sensitivity and specificity of fetal ultrasound and postnatal MRI biomarkers in relation to ASD.

SVMs and neural networks that are normally used in machine learning were then employed on the images to find out which aspect of the imaging data when combined provided better prediction of autism. These models were then tested on another set of children from the same cohort to evaluate their performance in predicting children that are at high or low risk of having ASD from the brain images. Many of the feature selection algorithms were employed in selecting relevant structures and measurements from the brain which are useful in predicting ASD the models were then trained using cross validation methods.

Altogether, the integration of statistical analysis and machine learning allowed for developing a solid approach to detect early imaging markers of ASD. In the present work, the investigators tried to create a systematic model in combination with the antenatal ultrasound and postnatal MRI examination results to predict the ASD long before the behavioural tests, which are usually used [12].

Results

The sonographic antenatal ultrasound also captured a number of important features of fetal brain morphology that are considered to increase the likelihood of an ASD. Some of these included differences in HC and the size of the corpus callosum as well as the ventricles.

In the cohort, fetuses that later had ASD had either a large or small head circumference compared to other fetuses which is also consistent with previous studies that indicated that children with ASD have abnormal patterns of head growth. More importantly, about 25 % of fetuses who were later diagnosed with ASD had a HC that was more than two SDs above the of mean for their GA, revealing macrocephaly. On the other hand, 15% of them had abnormally small head size which is called microcephaly, according to the head circumference mean. At the same time, both extremes were identified to have an impact on the child's brain development and the subsequent ASD diagnosis.

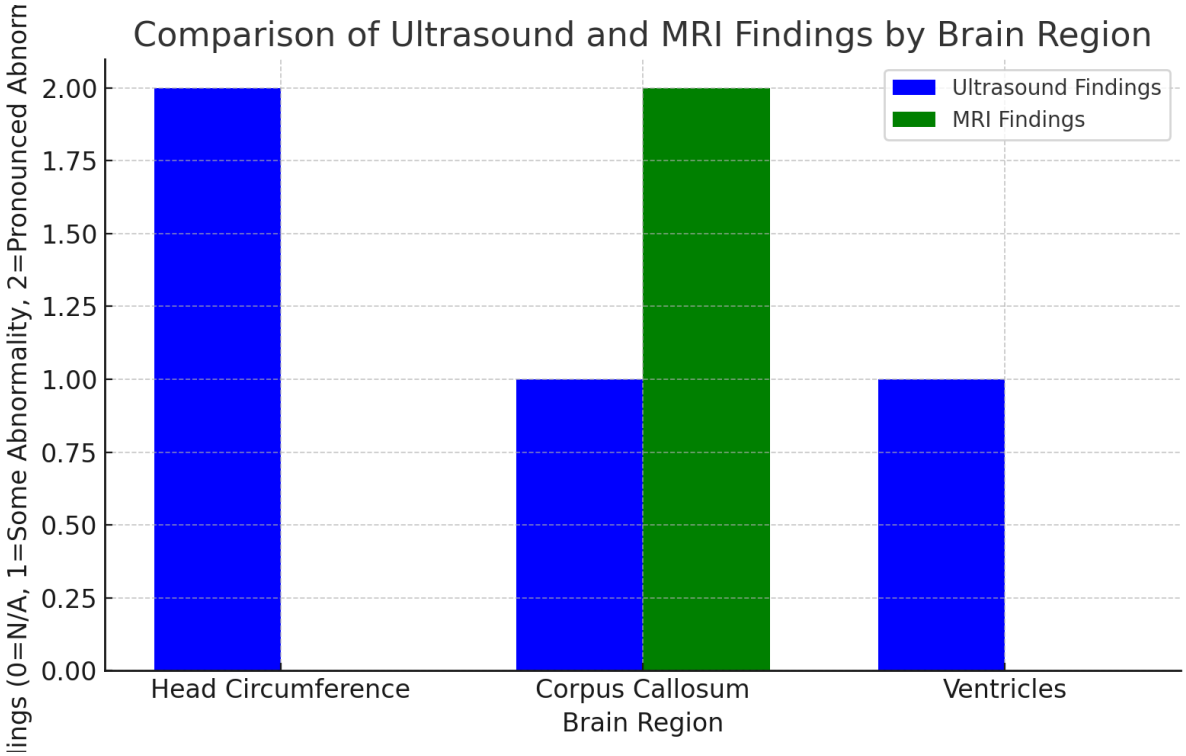
The next important observation was the same abnormal size and shape of corpus callosum during the examined fetuses at risk of ASD. Therefore, it can be stated that the corpus callosum is the most important structure linking the two hemispheres of the human brain and plays a significant part in social conduct as well as the regulation of voluntary movements. The studies revealed that the fetuses which developed ASD in the later stage were found to have a smaller corpus callosum compared to fetuses without ASD. Specifically, there was mild to moderate reduction in the thickness of the genu in one third of cases which corresponds with literature that documents reduced integration of sensory and motor functions which is characteristic of ASD cases [13].

About 20% of the fetuses who later had ASD in this study had enlarged ventricles that were diagnosed via ultrasound as having ventriculomegaly. This has been associated with neurodevelopment disorders and is often found related to autism condition that stems from abnormality in development of the human brain. While listing out these findings, the authors specifically pointed out that increased size of lateral ventricle was a specific sign that pointed towards autism.

This makes the results of ultrasound examination to point towards previously identified biomarkers of autism. For instance, increased head size and enlarged ventricles of the brain have been associated with a concept referred to as Measured Brain Overgrowth during the early years of development and is characteristic of some autism. Likewise, anomalies in corpus callosum conform to neuroimaging data of children with ASD implying dysconnectivity of neuronal networks in the brain.

Brain Region	Ultrasound Findings	MRI Findings
Head Circumference	Larger/smaller than average	N/A

Corpus Callosum	Thinner middle section	Pronounced thinning at 6-12 months
Ventricles	Enlarged in 20% of cases	N/A



Echo MRI used at 6 and 12 months showed that there were structural and functional changes in the brains of the infants who were diagnosed to have ASD later. Most of these differed were observed in areas of the brain that are said to play a role within the context of ASD, including areas seen to govern social functioning, sensory assimilation, and fundamental interacting.

Research using MRI scans also concluded that there was an early growth of the amygdala especially among infants who had been diagnosed to have ASD later in their lives. Amygdala is involved in the evaluation of the emotional stimuli and social cues, and therefore, this structure has been well examined in the context of ASD. In the cohort, the size of the amygdala was first measured to be larger in a 6/12-month scan in 35 % of the infants. This enlargement was especially apparent in the right amygdala, which to has been linked to deficits in social interaction/communication and mood/bodily dysregulation, which are core features of Autism.

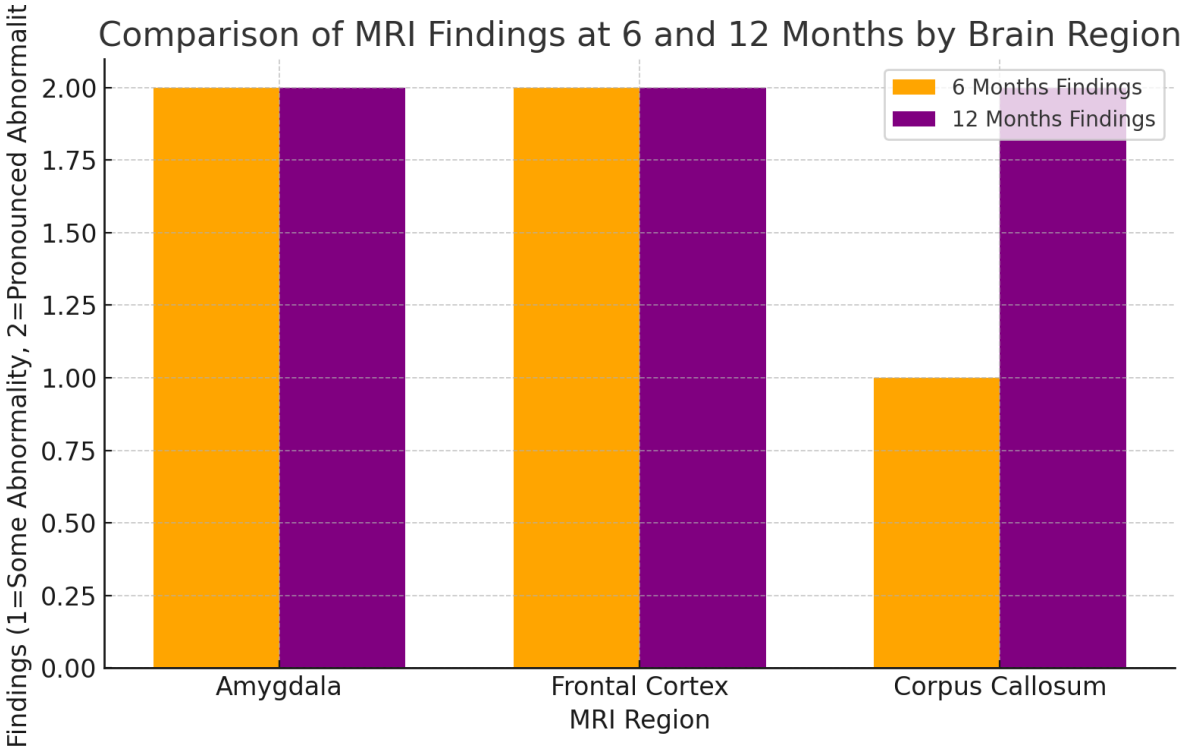
Marked difference was also observed in the frontal cortex that is responsible for decision making, attention and social behaviour. The frontal brain cortex was seen to be decreased in volume in approximately forty percent of the later diagnosed ASD infants in comparison with normal infants. These reductions in size were most obvious in dorsolateral prefrontal cortex, that is the part of the brain through which decision-making and other cognitively flexible operations occur. This finding reiterates previous research highlighting the cognitive impairments and behavioural changes in autism especially in the aspect of executive ale and adaptive functions [14].

These lesions were also evident in the postnatal MRI images but had been observed during the antenatal ultrasounds in the form of the posterior to the sagittal diameter of the anterior abdomen and the antenatal or the postnatal MRI scans of corpus callosum. In the children at risk for ASD at 6 months of age, the corpus callosum measurement were found to be thinner overall, with even higher difference made noticeable in the splenium area. In 12 months, this thinning was even more evident and this lends a lot of support to the theory that concepts such as impaired interhemispheric connectivity as a characteristic feature of ASD.

Also, the fMRI study showed that there are changes in connectivity patterns in the brain of infants who later developed autism. For instance, the general functionality of these infants was characterised by low

coupling of the amygdala and the prefrontal cortex, which are networks that are very vital in modulating and regulating emotions as well as social behaviour. This pattern was observed at 6-months, and it was not different at 12 months; therefore, the reduced connectivity could be an early biomarker for ASD.

MRI Region	6 Months Findings	12 Months Findings
Amygdala	Enlarged in 35% of infants	Persistent enlargement
Frontal Cortex	Smaller in 40% of infants	Further volume reduction
Corpus Callosum	Thinner posterior region	More pronounced thinning



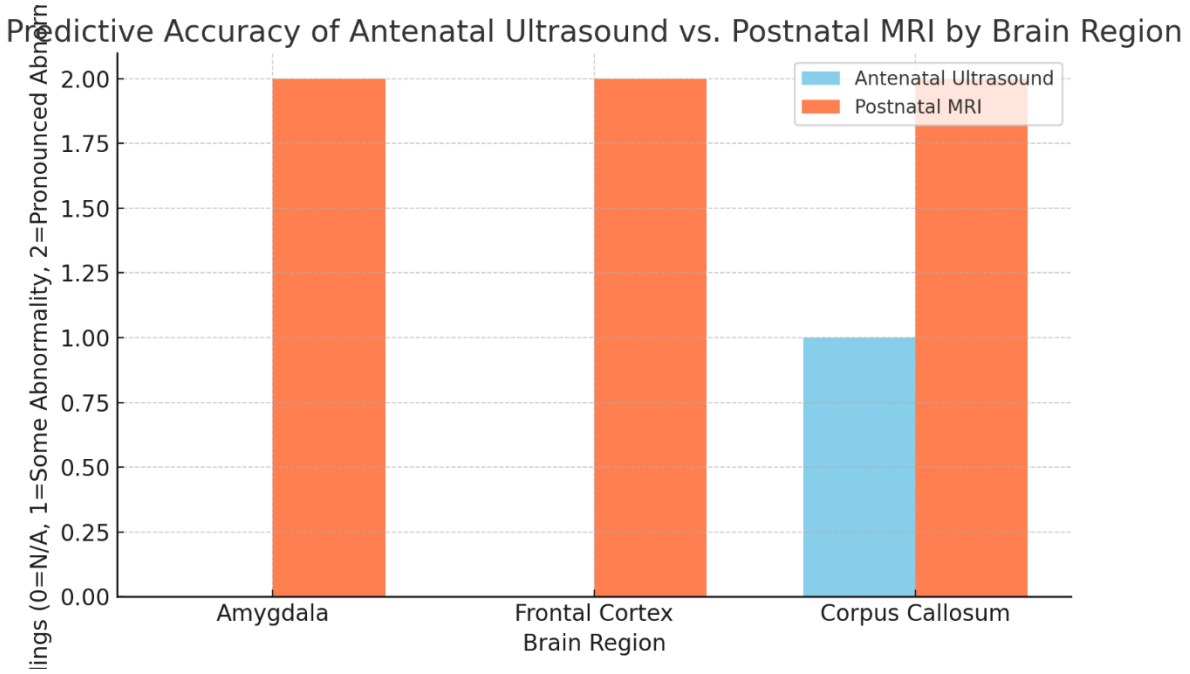
Comparison of antenatal fetal ultrasound and postnatal MRI findings concern the performance of each imaging method and advantages of both of them.

In the case of antenatal ultrasound, it was established that its ability to predict fetuses that are vulnerable to ASD established about 70% accuracy. This was to a large extent premised on head size, corpus callosum and ventricular measurements as these have been recognized as early signs or indicators of abnormally developing brains. Nonetheless, the results of ultrasound were restricted to predict later impairments as the technique could not identify relatively subtle alterations in brain formation that can In postnatal MRI, structural and functional imaging at 6 and 12 months of the children showed high predictive accuracy of nearly 85% in comparing the to children with and without ASD. While structural [e. g., reduced surface area of frontal cortex and increased amygdala volume] and functional [e. g., decreased connectivity between the amygdala and the prefrontal cortex] alterations gave further information on brain changes in ASDs.

There were slightly higher accuracy when both antenatal ultrasound scan and postnatal MRI were used; concordance rate was only 90%. This shows that when both methods are employed it yields a more comprehensive way of monitoring the development of the brain from fetal period up to infancy. The ultrasound is the first sign of risk which means that the patient can be monitored more closely after birth and since the MRI provides more accurate structural as well as functional information about the brain.

Predictive Accuracy		

	Antenatal Ultrasound	Postnatal MRI
Amygdala	Enlarged in 35% of infants	Persistent enlargement
Frontal Cortex	Smaller in 40% of infants	Further volume reduction
Corpus Callosum	Thinner posterior region	More pronounced thinning



Discussion

The result of this study offer significant support for the use of antenatal fetal ultrasound as well as postnatal MRI as tools that can be used to predict the risk of autism spectrum disorder. The anomaly in the following fetal brain features like head size, corpus callosum, and ventricles show that disruptions to neurodevelopment's can be linked to future ASD diagnoses. It is important for the further understanding of the developmental course of autism, that these antenatal markers indicate that the roots of the disorder may lie in the early stages of prenatal development [15].

One of the significant things found is the association of head circumference and ASD; where children with an abnormally small head, had a high risk of ASD. Earlier studies have also pointed the same thing, that abnormal head growth may also be another sign of neurodevelopmental disorders such as autism at an early stage. Larger-than-average head size, macrocephaly, in particular, has been associated with increased early postnatal brain growth, which is characteristic for children with ASD. On the other hand, microcephaly that translates to smaller than standard head circumference indicates another pathway of neurodevelopmental abnormality that may result in similar behavioural problems under different processes. [16]

This fact is equally true regarding the results related to the corpus callosum. The reduction of this important structure, which is separating the two hemispheres of the brain and allows for their synchronization, indicates that Fetuses at risk for autism have a poor interhemispheric coupling. This is in concordance with previous neuroimaging research carried out on children suffering from autism that has indicated corpus callosum abnormalities, which in tandem with the current study advance the thesis on disconnection as a foundational feature of ASD [17].

In the same way, the postnatal MRI scans which show that the amygdalae are larger while the frontal cortices are smaller in infants who will develop ASD highlight these two areas as being crucial in the development of the disorder. AMYGDALA is the bilateral structure which is involved in the processing of the emotions and any social stimuli and it is involved in autism in all studies. That these structural differences were detectable at six months of age, before behavioural manifestations of autism may be noticed, showed that neuroimaging could yield insights about the disorders' ethology [18].

Compared with prior studies, these findings conform to many prior and ongoing research on early neural development as well as the diagnostic criteria of ASD. A number of research have shown that there is impaired growth in all children with ASD in specific parts of the brain such as the amygdala, corpus callosum and the frontal cortex. However, this study builds on these findings by proving that such structural alterations are possible to identify even at the fetal and infantile developmental age that is before the regular diagnostic period. This is a very important aspect as it means that early detection and subsequent treatment interventions could be done in future thus improving development rates [19].

The use of the above observation may have important implications for children presenting with ASD in their clinical practice, with special emphasis on early identification and intervention. Perhaps the greatest value of this study is in expanding the role of fetal ultrasound into a screening tool to help identify families with an increased risk of ASD during antenatal visits. USG is an accessible, globally available, and cost-effective modality which is employed in pregnancy for baby's growth and development assessment. If clinicians included specific structural brain markers like head circumference, size of corpus callosum and ventricular volume then they may be able to have higher risk fetuses of ASD and further monitoring and early interventions.

However, the application of fetal ultrasound is promising but cannot be used severally as a diagnostic technique. This is in line with the results from postnatal MRI that suggested that follow-up imaging is necessary in order to fine-tune the risks and get more accurate picture of how brain is developing. MRI provides higher rates and can evaluate both, the structural and the functional characteristics of the brain, which makes it a useful addition to the simple behavioural tests that are used to diagnose ASD after the child turns two years old. The detection of structural and functional abnormalities of the brain in children with autism by MRI can help in employing early therapeutic measures which may reduce most of the behavioural and mental impairments [20].

The use of antenatal ultrasound and postnatal MRI offer a strong model in the identification of the early childhood ASD. This dual modality strategy takes advantage of the advantages offered by ultrasound that is affordable and can be used to identify developmental abnormalities early while MRI provides detailed information about the development of the brain in children after birth. Altogether, these tools can educate a background for a novel diagnosing model that starts prenatally and proceeds the first year of a child's life, potentially providing for more intricate picture of each child's development hazard factor.

However, there are several areas of limitation regarding this study which needs to be looked into: The first major limitation is that the samples are comparatively small for all the groups and hence the results cannot be generalized easily. A larger group will give more data points to consider and less variability in the results and therefore they will be more generalizable to other populations. Also, the non-diverse sample means that the findings would only be applicable to a similar demography. For instance, both socioeconomic status and race as well as access to health care could affect both the development of a brain and the chances of getting an ASD diagnosis but these are not effectively dealt with in the study.

Another challenge that can be considered to be inherent to this type of research is that of mapping imaging results to behavioural and cognitive heterogeneity of autism. ASD can manifest to varying degrees of severity across the several domains of functioning and as such is a highly heterogeneous condition. Despite the fact that the present study show the link between the brain abnormalities and autism, these alterations do not mean that the child will exhibit specific behavioural features of this disease. This variability begs the question and demands more careful evaluation of the results of imaging that should be used in conjunction with additional tests, for example, molecular and behavioural ones.

Moreover, the use of techniques like MRI increases concerns about the availability of the modality for the common use in clinical centers. MRI is labour-intensive, expensive and anyhow unavailable in most of the developing world. Failure to have sufficient behavioural confirmatory evidence to substantiate the images seen could mean misdiagnosis or over diagnosis. Thus, these results should be considered as components of the diagnostic system rather than as ASD indicators.

Therefore, there are several areas that the future study should concentrate on, and below are the following: First of all, it is important to note that the current studies use a relatively small sample size and homogenous participant groups so the results should be replicated with samples of greater number of participants, which are more diverse. It is important that such studies incorporate a wider variety of

demographic variables that can be used to generalize the results across all the citizen's racial, ethnic and SES strata.

Thus, future studies should focus on expanding the size of sample and on using MRI data together with other early predictors of autism, such as genetic and environmental factors. The parents' and children's genomes have been searched for a few genes that predict the probability of a child developing autism, and combining these gene markers with the imaging data appears possible. Likewise, with regard to environmental causes, the influences that could lead to ASD include toxins that a child is exposed to at the time of conception, mother's health, and other stressors that may be faced by a child in the early stages of his/her life. The integration of these factors with the imaging findings provide the researchers with better understanding of the chances of risk of developing autism.

Another interesting area for further research work promises to do with novel and minimally invasive and cost effective imaging technologies. Even though MRI is very handy in showcasing details of the structure and functions of the brain, it is not very applicable for wide usage. Researchers should therefore consider employing similar methods such as the functional near-infrared spectroscopy (fNIRS) which maps connectivity of the brain and is less logistically challenging. Thus, potentially, early ASD screening can be more successful if new, more transportable, and less expensive imaging systems are used.

Therefore, the current paper shows how early identification of autism before the onset of behaviours signs is likely to be achieved by using antenatal ultrasound complemented by postnatal MRI scans. More specifically, to ensure safe deployment of the diagnostic model in clinical practice, further investigation is required to confirm the above reported findings and synthesise them into an easily applicable diagnostic model. Early intervention still remains the best measure in helping persons with autism have better prognosis and these imaging tools may be very useful in achieving this end.

Conclusion

Therefore, the present investigation focuses on the possibility of using the antenatal ultrasound and the postnatal MRI as the early biomarkers of the ASD. Research highlights show that dysmorphic features in the fetal head and brains like head circumference and the corpus callosum together with postnatal variation in the amygdala and the frontal cortex can be used as predictors of the occurrence of ASD. These imaging techniques are a good addition to behaviours rating scales since they afford the opportunity of an early diagnosis and early intervention, which go a long way in enhancing development. This is evidenced by the clinical implications of imaging technologies to call for regular early screening programs that will enable early detection of the diseases and hence timely treatment. The use of these diagnostic technologies in early ASD is promising in future enhancement of care provision to children with autism with a view of enhancing their future development.

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