"The routine use of ultrasound in pregnancy is the biggest uncontrolled experiment in history."*Beverly Beech, birth activist*

I am writing this paper to explore the issues surrounding the use of ultrasound's and to raise awareness of the potential risks associated with repeated ultrasound scans and its possible link to cases of Autism.

Autism began to exponentially grow in the mid 1970′s. There are numerous reasons that caused this rise. Changes in diagnostic practices, awareness, and other 'social factors' have played a significant part.

Autism is a devastating neurological and biological disorder that typically affects children between the ages in 18 months to five years of age. **Autism currently affects 1 in every 88 children today. It is estimated there are over 1 million people in the United States alone with autism.** Autism affects each individual differently and at different levels of severity. Some people with autism are severely affected, cannot speak, require constant one-on-one care, and are never able to live independently. While others who have less severe symptoms, can communicate, and eventually acquire the necessary skills to live on their own. (14)

What concerns me about ultrasound is the lack of education. Many people don't know that ultrasound has side effects. Even practitioners often discount the idea that it can cause harm to a baby, even though there is scientific evidence that offers evidence to the contrary.

Ultrasound was originally developed in WWII to detect enemy submarines. After the war in 1955, a surgeon in Glasgow named Ian Donald, began to experiment with it for medical uses. Using beefsteaks as the "control" subject, he scanned the abdominal tumors he had removed from his patients and found that different tissues gave different patterns of sound wave echo. He quickly realized the potential of ultrasound for examining a growing baby in utero.

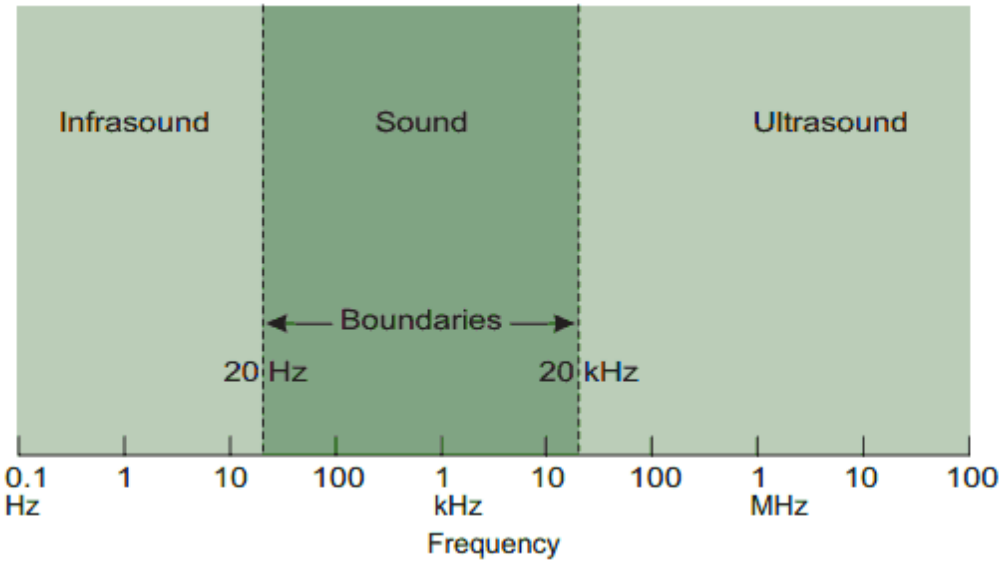
Initially, ultrasound was used only to investigate possible problems. For example, if there was bleeding in early pregnancy, it would be used to determine whether miscarriage was inevitable. Later in pregnancy, if breech or twins were suspected, ultrasound would be used to confirm that suspicion. In these cases, ultrasound can be very useful for a woman and her unborn child.

Over the years, ultrasound has come to be used as a routine scan at 18-20 weeks for all women. This is referred to as "**routine prenatal ultrasound**", or RPU for short. It involves scanning all pregnant women – whether a problem is suspected or not – in the hope of improving birth outcomes. (R1)

In the U.S., an estimated 65 to 70 percent of pregnant women have a formal scan in a diagnostic clinic, and many more women are scanned by their OB/GYN as part of their pregnancy visit. (R2) Ultrasound has been widely used in the medical practice for at lest 50 years. Diagnostic examinations include obstetric, abdominal, pelvic, and cardiac imaging.

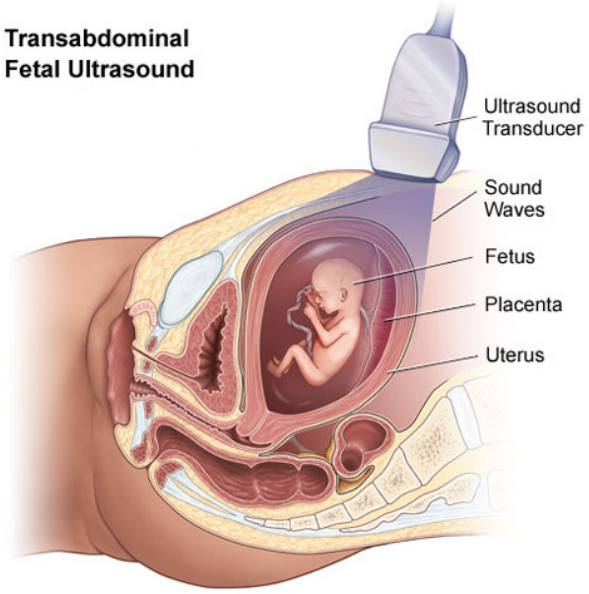
Obstetric RPU is used today for several reasons:
1. To predict the birth due date
2. To determine the sex of the baby
3. To detect potential abnormalities
4. To identify placenta previa (low lying placenta)
5.To assess specific markers, such as the length of woman's cervix and the amount of amniotic fluid at the end of pregnancy

Ultrasound and infrasound are mechanical waves at the extremes of the acoustic wavelength spectrum, approximately above and below, the human thresholds of hearing. Ultrasound is defined as acoustic waves at frequencies greater than 20 kHZ and infrasound is defined as acoustic waves at frequencies below 20Hz.

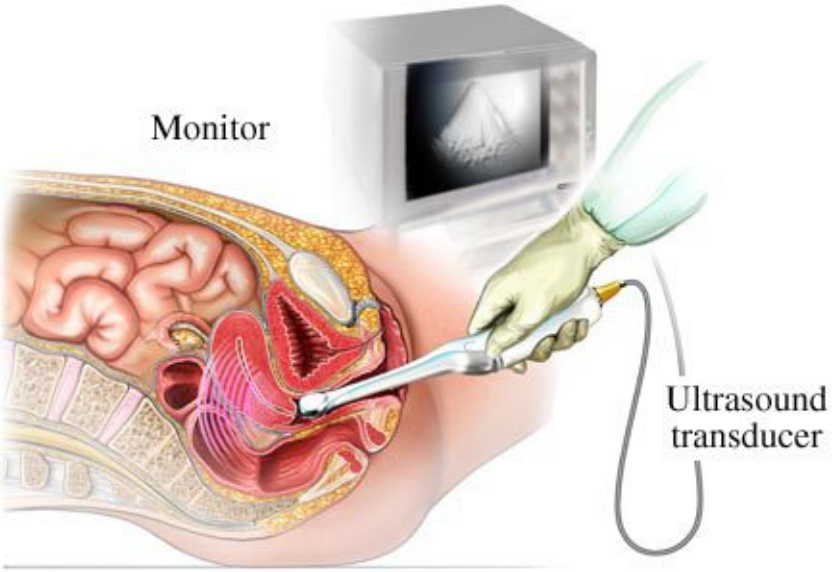


There are two common forms of ultrasound used in pregnancy. Transabdominal and Transvaginal.

In a transabdominal ultrasound exam, the health care provider or medical technician moves a handheld device, called a transducer, along the pregnant woman's abdomen. The transducer sends sound waves into the woman's uterus and also detects the echoes from those waves, which it then converts into electrical signals. The computer then assembles these signals into a picture. To get a clearer picture, the provider or technician covers the woman's abdomen with a thin layer of gel, which helps improve the transmission of sound waves.



Transvaginal ultrasound is a test used to look at a woman's reproductive organs, including the uterus, ovaries, and cervix. Transvaginal means across or through the vagina. (9) A probe is inserted through the vagina which sends sound waves into the woman's uterus and also detects the echoes from those waves, which it then converts into electrical signals, just like with the transabdominal ultrasound.



Ultrasound and infrasound can interact with biological tissues by mechanical and thermal processes. There is a wide range of chemical and physical consequences that high intensity can induce.

These sound waves are capable of producing the following physiological effects:

1. Increase in blood flow and temperature in local tissues
2. Production of gas bubbles that can put pressure on local tissues
3. Mechanical effects like movement of the fluid that surrounds your cells,which can also put pressure on local tissues

The conventional view on ultrasound scanning during pregnancy is that the intensity and duration of sound waves that are used for scanning are not enough to produce these physiological effects at a level that is harmful to a fetus. However, this conventional view could be said to be influenced by the number of dollars that are being made by this industry. (15)

To expand upon these physiological effects, the chemical effects of ultrasound can be divided into three general types:
1. neat liquids: In chemistry, the term "neat" means that the substance has not been mixed with anything else.
2. heterogeneous liquid–liquid systems
3. heterogeneous liquid–solid systems.

At high levels of exposure, ultrasound is capable of causing permanent damage to biological tissues, including teratogenic effects, through heating, acoustic cavitation and radiation force. Teratogenic effects is the branch of medical science concerned with the development of physical abnormalities during the fetal or early embryonic stage.

Liquids irradiated with ultrasound can produce bubbles. These bubbles oscillate, growing a little more during the expansion phase of the sound wave then they shrink during the compression phase. Under the proper conditions these bubbles can undergo a violent collapse, which generates very high pressures and temperatures. This is called cavitation. (6)

Once the cavity has overgrown, either at high or low sonic intensities, it can no longer absorb energy as efficiently. Without the energy input the cavity can no longer sustain itself. The surrounding liquid rushes in, and the cavity implodes and can generate an intense shockwave. It is the implosion of the cavity that creates an unusual environment for chemical reactions. (6)

The compression of cavities when they implode in irradiated liquids is so rapid than little heat can escape from the cavity during collapse. The surrounding liquid, however, is still cold and will quickly quench the heated cavity. Thus, one generates a short-lived, localized hot spot in an otherwise cold liquid. (6) Ultrasound can produce temperatures as high as those on the surface of the Sun and pressures as great as those at the bottom of the ocean. In some cases, it can also increase chemical reactivities by nearly a millionfold. (7)

When a liquid is subjected to ultrasound, not only does chemistry occur, but light is also produced. Such "sonoluminescence" provides an alternate measure of the temperature of the high-energy species produced during cavitation. High intensity ultrasound creates localized hot spots in liquids through the process of cavitation. Local heating produces excited states of molecules that emit light, just as they do in a flame. Sonoluminescence is the emission of short bursts of light from imploding bubbles in a liquid when excited by sound.

Researchers from Yale University School of Medicine report that a small, but significant, number of nerve cells in fetal mouse brains did not migrate to the correct location after being exposed to prolonged ultrasound waves. This process of cell migration, known as neuronal migration, is essential for proper brain development. (12)

At lower levels, such as those used for diagnostic purposes, ultrasound does not generally cause heating beyond the normal physiological range, nor does it cause cavitation in the absence of pre-existing gas bubbles.

The degree to which ultrasound machines raise temperatures in the tissues depend on which tissues are scanned. Bone heats more than soft tissue, which in turn heats more than fluid. Heating is also dependent upon exposure time, the intensity of the machine, and whether the transducer is held stationary or moved frequently. (16)

Doppler ultrasound, which uses continuous rather than pulsed waves, has been shown to cause significant heating – especially in the baby's developing brain. A recent study suggests that heating in late-pregnancy fetal tissues exposed to normal pulsed and continuous Doppler ultrasound may be higher than what is regarded as safe: 2.5 to 10.4 degrees F (1.4 – 5.8 C) respectively. (16)

A 1997 study found that significant temperature increases can occur at or near to bone in the fetus starting in the second trimester, if the beam is held stationary for more than 30 seconds in some pulsed Doppler applications. This in turn can lead to heating of sensory organs incased in bone. (16)

Though both animal and human studies have shown that temperature elevations can cause abnormal development and birth defects, so far human studies have not shown a direct causal relationship between diagnostic ultrasound exposure during pregnancy and adverse effects to the developing baby. (16)

However, it must be pointed out that all human epidemiological studies were conducted with commercially available devices predating 1992, with acoustic outputs not exceeding an intensity of 94 mW/cm2.

Current limits in the U.S. have risen dramatically, and now allow intensities of up to 720 mW/cm2 – more than 7 times the limit in 1992. This means we have **no large, population-based studies examining the effects of ultrasound at the much higher intensities commonly used today**. (16)

Growing concern over ultrasound (US) includes not only the increased prevalence of its use, but also its deregulation in the 1990s. Denser body tissues necessitate higher intensity outputs in order to penetrate deeply enough to produce images of adequate clarity and resolution. With increasing rates of obesity and the consequent need to accommodate US for use on increasing body sizes, the FDA has loosened regulations on the maximum intensity allowed for clinical use. (4)

Despite the above concerns, in the 50 years since introduction into clinical practice, US has not been directly associated with any significant health risk to the fetus or mother. The American Institute of Ultrasound in Medicine has stated that prenatal US should be performed according to the ALARA principle (As Low As Reasonably Achievable), and that it should be performed only with a valid medical indication and with the lowest outputs necessary. Additionally, both the American Institute of Ultrasound in Medicine and the Food and Drug Administration have discouraged the use of US for "keepsake fetal imaging", although this remains a prevalent issue.

The FDA is aware of several enterprises in the U.S. that are commercializing ultrasonic imaging of fetuses by making "keepsake" videos and portraits. In some cases, the ultrasound machine may be used for as long as an hour to get a video of the fetus. (10) Keepsake operations use the same ultrasound scanners that are used for diagnostic imaging in hospitals and clinics. The goal of a keepsake operation, however, is to produce pleasing pictures rather than diagnostic information.

Keepsake 3D Portrait

The most experienced sonographer will routinely encounter difficulty obtaining favorable pictures in a timely manner for diagnostic purposes, and not all keepsake facilities employ sonographers with the training and experience required to produce acceptable images. In the hands of an inexperienced operator, a scanner could expose a fetus for prolonged periods and at higher ultrasound intensities than are usual in a medical environment. (11)

Below is a chart breaking down the maximum recommended timing for an ultrasound examination.

TABLE 1 Recommended Examination Timings

ALLOCATED APPOINTMENT TIME	ULTRASOUND EXAMINATION EXAMPLE
15 minutes	Follow up of screening for abdominal aortic aneurysm
	Follow up of screening for endometrial hyperplasia
20 minutes	Pregnancy dating
	3rd trimester review
	Referral for gall bladder disease
	Referral for urinary tract pathology
	Referral for testicular lump
	Referral for thyroid mass
	Follow up of known liver disease (eg: cirrhosis / hepatitis)
	Follicular tracking for assisted reproductive techniques
	Referral for gynaecological indications
	Peripheral vascular referrals (eg: DVT / carotid stenosis)
30 minutes	1st trimester pregnancy screening (nuchal translucency)
	2nd trimester routine anomaly screening
	Paediatric / neonatal referrals
	Investigation for diffuse liver disease
	Investigation for portal hypertension
	Breast Referrals
	Cardiac Referrals
45 minutes	Interventional procedures - biopsies, contrast, fetal therapy
	Known twin pregnancy including 1st trimester screening
60 minutes	Bedside examinations (total time away from department)
	Intra-operative procedures

Additionally, litigation factors may also be driving the increasing use of US. Failure to perform an ultrasound or other medical tests at appropriate times is commonly cited in lawsuits against doctors, midwives, and hospitals. (4)

In general, RPU is accurate for predicting birth date when scans are performed in the early stages of pregnancy. The estimated due date (EDD) calculated by a scan at 7-8 weeks will be accurate to plus or minus 3-4 days. However, calculations of EDD based on a woman's menstrual cycle can be just as accurate.

What about detecting abnormalities? Studies show that RPU detects between 35-80% of the 1 in 50 babies that have significant abnormalities at birth. The larger centers with better trained sonographers have rates toward the higher end of the scale, but even major centers miss 40% of abnormalities. This is because many abnormalities are difficult or impossible to detect with RPU. Heart and kidney problems are unlikely to be picked up, as are some markers for Down syndrome. Cerebral palsy, autism, and other markers of intellectual disability are impossible to detect.

Then there's the small but significant chance that an abnormal finding may be a false positive. A UK survey showed that for 1 in 200 babies aborted for supposed major abnormalities, the diagnosis on post-mortem was less severe than predicted by ultrasound, and the termination was probably unjustified. In the same survey, 2.4 percent of babies diagnosed with major malformations – but not aborted – had conditions that were significantly over- or under diagnosed. Two other studies have shown false positive results in roughly 10% of babies diagnosed with structural abnormalities. And in some cases, the abnormalities spontaneously resolve without intervention.

Ultrasound scanning for placenta previa is mostly accurate, but almost all women who test positive for it on a scan will be unnecessarily worried. Studies show that the placenta will move up and not cause problems during birth for 80 to 100 percent of women, and that detection of placenta previa by RPU is not safer than detection during labor.

All of this might explain why organizations like the American College of Obstetricians and Gynecologists recommend scans only for specific reasons, including uncertain due dates and fetal assessment, and advises that routine prenatal scans are cost-effective only when done by ultrasound technicians working in high-level centers.

The important question is: is RPU necessary and effective for these uses? Studies on RPU over the years have consistently shown that it does not improve birth outcomes as measured by clinical endpoints such as perinatal mortality and morbidity.

As often happens in medicine, techniques which may be of value to a small percentage of people slowly become adopted for routine use without prior study of benefits. The problem with this approach, is that when we perform a procedure or administer a treatment to a segment of the population without properly testing it beforehand, we are

essentially conducting an uncontrolled scientific experiment on that population – often without their understanding and consent. And in this case, we are performing that uncontrolled experiment on two of the most vulnerable populations: pregnant women and babies in the womb. (R1)

Before you allow ultrasound scanning to be performed during pregnancy, please consider the following points:

1. Ultrasound scanning of pregnant women has been shown to significantly increase the likelihood of miscarriage, preterm labor, and even infant mortality.

2. Pregnant physiotherapists who provided ultrasound treatments for more than 20 hours per week were found to have an increased risk for spontaneous abortions.

3. One of the reasons used to support ultrasound scanning for pregnant women is that it can help to diagnose a condition called placental praevia. This is a condition where the placenta is implanted in the lower part of a woman's uterus, which can cause bleeding in the third trimester and increase her chance of being encouraged to have a caesarean section. A study of 4000 women found that of 250 women who were scanned and diagnosed with placental praevia, only 4 actually had placental praevia upon delivery. Who knows how many unnecessary caesareans have been done and how much needless anxiety women have experienced due to incorrect diagnoses of placental praevia with ultrasound?

4. Using ultrasound scanning to detect serious problems before birth **does not** necessarily save lives or reduce illness. There is evidence to suggest that using ultrasound to attempt to detect problems while a baby is in the womb can do more harm than good.

5. There is evidence to support that children who have been exposed to ultrasound while in their mothers' bellies have a greater chance of suffering from dyslexia and other speech and learning problems than children who have not been exposed to ultrasound. (15)

6. No matter what intensity and duration of ultrasound waves are used, there is always a possibility of these waves creating unnecessary thermal and physical pressure to a growing baby. Why take this risk?

7. There is always a possibility of practitioner error and/or a defective machine that can result in a higher than intended dose of ultrasonic waves to your baby. (15)

Resources:

(1) http://chriskresser.com/natural-childbirth-iia-is-ultrasound-necessary-effective-in-pregnancy

(2) http://www.ncbi.nlm.nih.gov/pubmed/14717305/

(3) https://www.change.org/petitions/health-risks-of-prenatal-ultrasound-the-urgent-need-for-more-research-and-regulation

(4) http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3646553/

(5) Reher P. et al. Ultrasound stimulates nitric oxide and prostaglandin E2 production by human osteoblasts. Bone. 2002;42:236–41. doi: 10.1016/S8756-3282(02)00789-5. [PubMed]

(6) http://www.scs.illinois.edu/suslick/sonochembrittanica.html

(7) http://www.uzaktanegitimplatformu.com/UEP/uep_doktora/sonokimya/sonokimya_download/The%20Chemistry%20of%20Ultrasound.pdf

(8) http://www.womensdocs.com/lib/pdf/First_Trimester/Ultrasound_in_Pregnancy.pdf

(9) http://www.nlm.nih.gov/medlineplus/ency/article/003779.htm

(10) http://www.fda.gov/MedicalDevices/Safety/AlertsandNotices/PatientAlerts/ucm064756.htm

(11) http://www.diagnosticimaging.com/articles/keepsake-ultrasound-raises-medical-hackles

(12) http://www.webmd.com/baby/news/20060807/ultrasound-affects-fetal-brain-in-mice

(13) http://www.bmus.org/policies-guides/SoR-Professional-WorkingStandards-guidelines.pdf

(14) http://www.tacanow.org/about-autism/

(15) http://drbenkim.com/articles-ultrasound-pregnancy.html

(16) http://chriskresser.com/natural-childbirth-iib-ultrasound-not-as-safe-as-commonly-thought