

# The Fetal Tele-Ultrasound Project in Queensland

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## Abstract

*The need for access to tertiary centre experts for those living in rural and remote areas of Queensland is well recognised. With an estimated population of 3.3 million people of whom 55% live outside the capital city, Queensland is ideally suited to telemedicine, as it provides a potential opportunity to improve access to specialist care. Congenital fetal abnormalities are the major causes of perinatal morbidity and mortality. With only two Maternal Fetal Medicine Specialists in Queensland located in a major teaching hospital in Brisbane, the opportunity to use videoconferencing technology to develop a tertiary level tele-ultrasound service presented a challenge – that is, to find a technical and clinical solution to enable such a service. We report on some of our practical experiences and difficulties in establishing such a service.*

## The need for Tele-Ultrasound

Queensland is a large state with a low population density. It has an estimated population of 3.3 million people, is the second largest state in Australia, and covers 1.7 million square kilometres (ABS, 1994). Much of this population is concentrated in Brisbane, Townsville and Cairns. There are approximately 48,000 babies born in this state each year, of which about 10,000 are in North Queensland (Queensland Health, 1999).

Congenital fetal abnormalities are the major cause of perinatal morbidity and mortality. Referral to a tertiary maternity centre is indicated when fetal congenital anomalies are suspected so that accurate diagnosis and counselling can be provided to facilitate informed decision-making.

The Mater Mothers' Hospital at Brisbane is the only tertiary hospital in Queensland staffed with full-time Maternal Fetal Medicine Subspecialists accredited by the Royal Australian and New Zealand College of Obstetricians & Gynaecologists. It has full access to a team of perinatal specialists who offer advice and management to complicated perinatal problems. Kirwan Hospital for Women in Townsville is the main tertiary maternity unit for North Queensland.

Traditionally, high-risk patients in North Queensland have either been flown to Brisbane for fetal assessment, or their ultrasound videotapes have been sent for assessment. Neither is satisfactory, with the former being expensive to the Healthcare System, and disruptive to the families concerned. Diagnosis from videotapes can also be problematic, as the tape may not contain the detailed ultrasound views required by the specialist to make a definitive diagnosis. Compounding these issues is a recognised shortage of fetal medicine services in Queensland.

In a bid to overcome these problems, clinicians at the Mater Mothers' Hospital (Brisbane) and Kirwan Hospital for Women (Townsville) seized the opportunity to use telemedicine technology, which is ideally suited to deliver medical expertise across a geographic separation. Both hospitals are part of the Queensland Health Telemedicine Network. A project team of key health care professionals in the two centres, 1,500km apart, "assembled" to collectively determine how real-time fetal ultrasound consultations could proceed. The main objective being to

find a clinical and technical solution that would offer live real-time fetal ultrasound, and face to face consultations with the patients, in the presence of the multi-disciplinary team of specialists from both centres. This would facilitate communications between the clinical teams, reduce the stress and anxieties experienced by the families and at the same time reduce the cost to the Healthcare System.

One barrier to telemedicine is the running cost, especially if high bandwidths are required. The transmission of medical imaging information involves high volumes of data. In general, the transmission of still images does not pose major problems, as the slight delay in transmission is usually acceptable. The transmission of real-time moving ultrasound images however imposes a challenge to the technology. Recognising this, vendors from the telecommunication industries donated their time to this project, determined to find a technical solution for this complex application. The purpose of this paper is to share some of our practical experiences and difficulties in establishing such a service.

## Project planning and pilot phase

### Personnel

Two teams were set up. The "technical group" consisted of Mater staff, private vendors and telehealth consultants. They met regularly in Brisbane to evaluate a range of commercially available videoconferencing systems and a range of bandwidth speeds that could be acceptable for clinical trial. The private vendors and telehealth consultants donated valuable technical expertise to ensure that the project remained viable, especially during periods of technical frustration in the pilot phase.

The "clinical group" included key clinicians from both the Mater and Kirwan, who met regularly via videoconferencing to resolve any clinical problems. All the clinicians involved have direct and extensive experience in the management of complex perinatal consultations. At the remote end (Kirwan Hospital), the team consists of obstetricians, experienced sonographers, a project officer, and administration support staff. The project officer has a key role in communication between the local team and project team. The Mater team (receiving end) provides the overall project planning, direction, and co-ordination.

### Equipment

The first phase tested eight commercially available room-based and PC-based videoconferencing systems. The room-based system contains a more powerful video codec and uses a television style monitor in a large room, whereas a PC-based system uses a computer monitor. The difference between the two systems is the video image quality transmitted through to the screen, with the room-based system and television style monitor having the better quality of images.

All systems tested were loaned by a variety of companies for testing and evaluation. The cost of each type of system varied from several thousand dollars (PC-based) up to \$50,000 (room-based). A standard ultrasound videotape of images from 3 normal fetuses (at first, second and third trimesters) is played through each of the videoconferencing systems at varying bandwidths and evaluated by 4 observers blinded to the systems and bandwidths used (Chan et al, 1999). Two room-based videoconferencing systems (PictureTel Venue 2000 and Vtel LC5000) were assessed to have the best clinical potential. Both systems were then subjected to further assessment and evaluation by the same observers initially using videotapes of fetuses with abnormalities, and then using live images transmitted through the ISDN (integrated systems digital network) link between the two hospitals (Chan et al, 1999).

### Bandwidth requirements

The four observers assessed the following bandwidths for image transmission: 256, 384, 512, 768 kbit/s, and 1.15, 1.54 and 1.92 Mbit/s. A network interface unit such as Promptus is used to dial up on demand the varying bandwidths. The images were displayed on a high-resolution monitor, and the observers were blinded to the equipment or bandwidth used. The results found that 384 kbit/s is the minimum bandwidth required for adequate image transmission (Chan et al, 1999). However, it is also concluded that while most fetal ultrasound

assessments can be performed at 384 kbit/s, 1.152 Mbit/s should be available for evaluation of fine anatomical details or for difficult cases such as congenital cardiac problems (Chan et al, 1999).

## Clinical consultations

### The teams

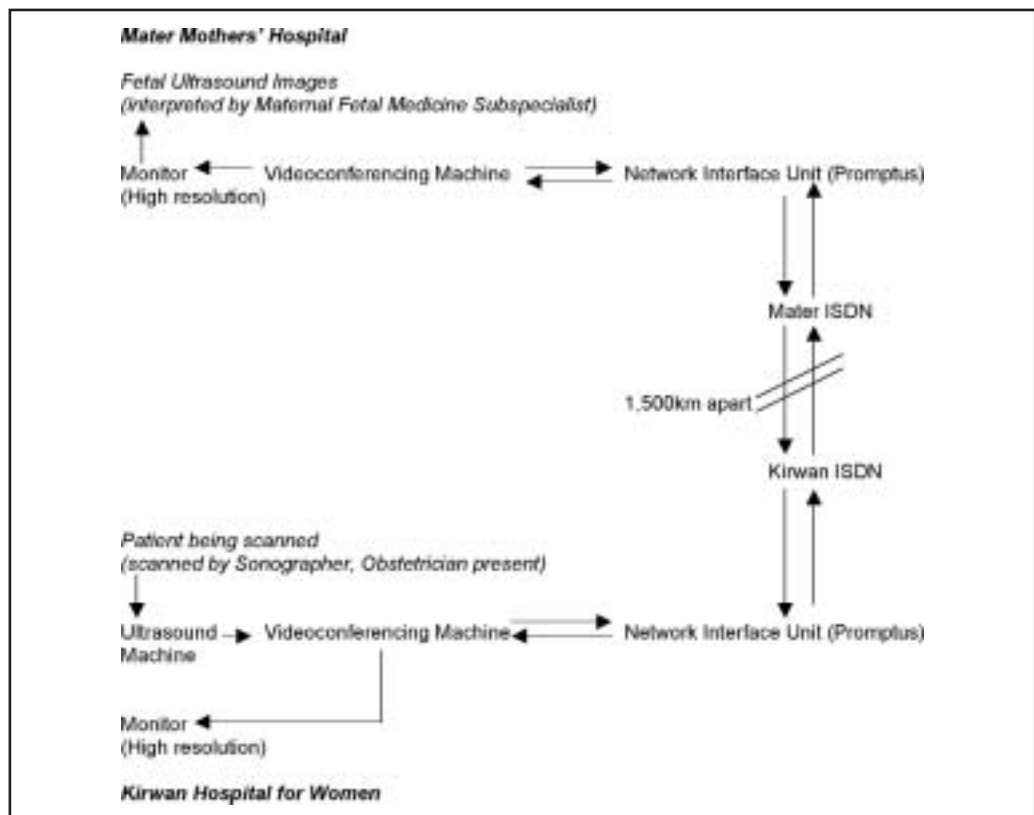
The number of staff involved during a consultation is variable. At the remote end, 2 or 3 staff are usually involved (the referring obstetrician and 1 or 2 sonographers). Depending on the complexity of the case, and with the permission of the patient, there may be other disciplines of staff present (neonatologist, paediatric cardiologist, nephrologist, visiting specialists, midwives, social worker, obstetric registrar or medical students).

At the receiving end, a midwife or a senior sonographer usually assists the Maternal Fetal Medicine subspecialist. Given the relatively large numbers of staff involved, it is important to ensure that privacy is carefully respected at all times.

### Equipment and room set-up

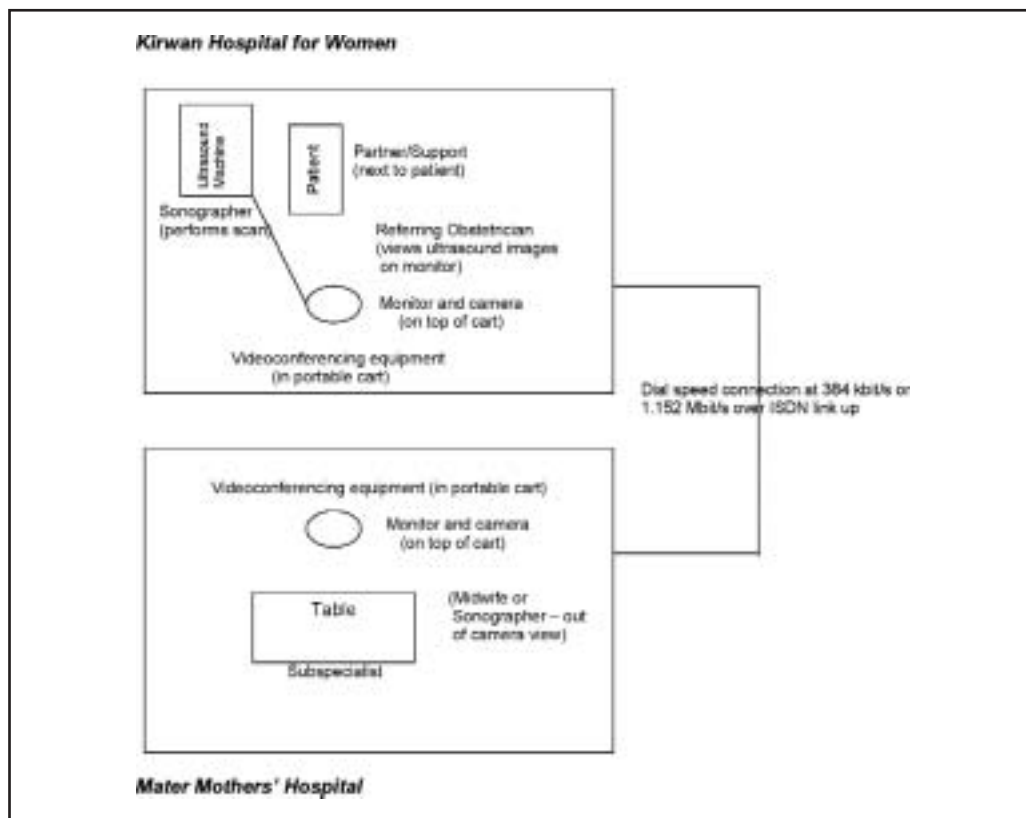
In over 93% of the consultations, the set up time of all the equipment for a consultation at the remote end is less than 30 minutes. During the early stages of the project, this could take up to 60 minutes or longer. This is because the videoconferencing equipment is moved between rooms, as well as the staff learning to operate the system. This includes connecting the ultrasound machine to the videoconferencing unit and monitor, and connecting this to the network interface unit and to the ISDN lines (Figure 1).

**Figure 1: flow diagram of equipment set up for fetal ultrasound telemedicine consultation**



In the first year of the project, the ultrasound machine and the patient couch at the remote end was moved into a conference room, where the equipment is kept, before the consultation could take place. The videoconferencing equipment is now fixed onto a portable cart so it can be easily moved into and out of the ultrasound room thus reducing the set-up time. The room set up at both sites (Figure 2) optimises the space in each room to ensure the mother is the focus of the consultation rather than the technology. The equipment at the receiving end is set up in a dedicated conference room within the hospital.

**Figure 2: room set-up at both centres**



A weekly consultation time schedule is drawn up. Despite this, delays in the commencement of consultations can still occur. Reasons for these delays include the subspecialists being held up with their own patients (20%), or technical problems with the videoconferencing system and/or network interface unit (11%). Overall, the waiting time for the commencement of consultations is less than 15 minutes (69%).

## The consultation

Before the consultation, clinical information is faxed to the receiving end. At the start of the consultation, the remote end dials in at a bandwidth speed of 384kbit/s over the ISDN link. Interactive two-way microphones allow direct communication between the two centres. The Maternal Fetal Medicine subspecialist is introduced to the patient (and partner) at the remote site, face-to-face over the link. Background information is clarified, and rapport is established between the patient and the subspecialist over the link. The sonographer at the remote end then performs the real-time ultrasound examination under the direction of the subspecialist. At the end of the consultation, the subspecialist counsels the parents on the diagnosis and prognosis of the condition, including the advisability for invasive investigations. The management plan is discussed and agreed to with the clinicians at the remote end. A report is generated after the consultation and is faxed to Kirwan Hospital within 24 hours.

Real-time interaction is one of the principal reasons for the success of our project. Patients can access and have instantaneous feedback from the subspecialist without the stress of physical removal from their community. It also facilitates improved communication between the two hospitals, provides additional education and training of staff at the remote end, and reduces risks of liability that may arise when vital information is missed in pre-recorded examinations. However, it does involve the collective availability of both teams at the same time, and is obviously harder to organise. This can be overcome with timely scheduling.

The clinical experience of the project has been previously reported (Chan et al, 2000; Chan et al, 2001). Of the initial 120 consultations, some modifications to the clinical diagnosis were made in 41% of the cases, and modifications to the management plan in 40% of the cases. All 120 cases have birthed, and outcome data has been received on all but one case (this mother moved overseas). All antenatal diagnoses have been confirmed. Only one problem has been missed: one fetal assessment for an abdominal cyst that is considered benign. The fetus subsequently died in utero, and later found after birth to have suffered from Down Syndrome (Chan et al, 2001).

### Technical difficulties

New technology is a fact of life. It is not foolproof – it either works well, or it comes with a fair share of problems. While desktop computers and elaborate equipment is a common day usage in clinical practice, most clinicians do not have the time to troubleshoot technical problems. It is important that technical assistance is easily available, to facilitate the uptake of telemedicine by busy clinicians. A review of our first 160 consultations (between June 1998 and August 2001) showed that re-transmission during a consultation occurred in 32 cases (see Table 1).

In the majority of cases, the cause is due to loss of transmission in the network. Most of the time, the call could be reconnected quickly, but there were some instances where the consultation had to be completed over the telephone. The problems encountered included 'freezing' of video images, loss of audio, collapse of the local phone exchange (once) and corrupted software in the videoconferencing unit or network interface unit. Readily available technical support and "help desk" facilities are vital so that all problems can be reported to the same group and handled quickly. While most problems can be solved remotely, the availability of a technician on-site is invaluable.

**Table 1: reasons for re-transmission of call**

Reasons for re-transmission of call	%
Loss of transmission during call	63%
Quality of video images	16%
Quality of ultrasound images	13%
Sound quality	8%

### Participants' evaluation

The whole experience of a tele-ultrasound consultation can be quite overwhelming for the patient, as most have never used telehealth technology before. Women from all over Northern Queensland (Table 2) are referred for tertiary consultation. Analysis of the first 160 clinical consultations showed that 129 (81%) were first consultations and the remaining 31 (19%) were second or subsequent consultations, with three women having 5 tele-ultrasound consultations during their pregnancy.

**Table 2: tele-ultrasound – place of referral from June 1998 to August 2001**

Centre	Postcode	First Consult	Subsequent Consult	Total
Townsville	4810-4817	72	19	91
Airlie Beach	4802	1	0	1
Atherton	4883	1	0	1
Ayr	4807	3	0	3
Bowen	4805	4	1	5
Cairns	4870	13	6	19
Charters Towers	4820	2	0	2
Clermont	4721	1	0	1
Cooktown	4871	1	0	1
Ingham	4850	4	1	5
Innisfail	4860	5	0	5
Julia Creek	4823	1	0	1
Mackay	4740	7	0	7
Mareeba	4880	2	0	2
Mit Isa	4825	5	2	7
Palm Island	4816	1	0	1
Port Douglas	4871	1	1	2
Proserpine	4800	3	0	3
Rockhampton	4700	1	0	1
Tully	4854	1	1	2
<b>Total</b>		<b>129</b>	<b>31</b>	<b>160</b>

A questionnaire survey of the perceptions of patients and their experiences of tele-ultrasound consultations is completed at the end of each consultation. There were 98 (76%) completed responses returned from the first 129 consultations. The results showed that 87% of the women had not used videoconferencing before. The 13% of women who had used videoconferencing before had mainly used it in the course of their work. 94% of the women strongly agreed or agreed when asked if their privacy and confidentiality were maintained during the videoconference. All women who responded indicated that they would recommend this type of videoconferencing to others.

## Conclusions

In rural and remote regions where there are limited numbers of Healthcare specialists, telehealth may facilitate improved access to health care, enhance quality of care, and provide education and support to the local health care team. From our experiences, collaboration and cooperation from participating centres are essential, and any differences or misunderstandings need to be managed early to avoid conflict that may jeopardise the project. It is important to recognise that telehealth cannot replace local services, and for it to be seen as a support rather than as a threat to local services.

From our humble pilot in 1997, we have established a regular weekly tele-ultrasound consultation service that is valued by both clinicians and patients. It is the only service of its kind in the world that involves such long distances (1,500km), and such high-risk consultations. At present, the minimum bandwidth requirement of 384kbit/s prevents many regional centres from accessing the service. However, Queensland Health is currently installing a larger network, after which many other regional hospitals in Queensland may have ready bandwidth access at 384kbit/s.

Telehealth is a rapidly evolving field. Newer versions of videoconferencing systems are now more affordable, smaller, and less costly compared to the earlier versions that were often more expensive and not necessarily user-friendly. Transmission using the internet protocol (IP) may also prove to be much less costly when compared to ISDN. Initial investigation by our group has already shown that real-time transmission of ultrasound images using IP networks has acceptable qualities (Chan et al, 2002). We are also researching the feasibility for the use of compressed videoclips from portable digital ultrasound machines transmitted via the internet (Begg et al, 2001). If successful, these strategies would enable even more remote sites to benefit from such services.

## Acknowledgements

The authors are grateful to Queensland Health and Queensland Telemedicine Network for providing funds for the pilot project, Telstra Corporation Limited (Australia) for free installation and rental of the ISDN lines during the pilot phase of the project, and the private vendors who provided technical support and equipment for evaluation in the pilot project – and particularly PictureTel Australia and VTel Australia, who provided their equipment on loan for an extended period and Vantage Systems for technical support. We also acknowledge the assistance of Dr Leith Hayes, Dr Alan Taylor, Dr Rob Whiting and the TARDIS Project team at the Royal Brisbane Hospital; Dr John Whitehall, Colleen Walters, Sonja Brennan, Kate Lessing, Dr Eric Green and the staff at Kirwan Hospital for Women; and Dr Robert Cincotta, Dr David Cooper, Alison Lee-Tannock, Donna Amaraddio and the staff in Maternal Fetal Medicine at Mater Mother's Hospital. Finally we wish to acknowledge the help of the many patients who have returned the evaluation forms for assessment.

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