

# Telemedicine and Ultrasound in Obstetrics and Gynecology

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## Abstract

Telemedicine refers to the use of telecommunication technologies for the purpose of transmitting medical information between physically separated clinical sites, in order to provide health care to patients at such remote locations. Additionally, telemedicine can be used to educate health care workers and students at distant locations. Telemedicine technologies can be categorized as either 'store-and-forward' or 'interactive' (or 'synchronous/asynchronous') depending on the timing of the transmission of information. This review focuses on applications of telemedicine to the field of obstetric and gynecologic (Obs/Gyne) ultrasound. It also examines the utilization patterns of telemedicine, as well as its costs and benefits. Finally, this article examines the role of telemedicine in medical education, specifically also with reference to Obs/Gyne ultrasound.

**Keywords:** Telemedicine, ultrasound, obstetrics, education, cost, technology.

## DEFINITION AND SCOPE OF TELEMEDICINE

Telemedicine has been defined as the use of modern telecommunications and information technology for the exchange of medical information between physically separated sites of clinical practice in order to provide clinical care (and/or medical education) at a remote location. Literally, telemedicine means medicine practiced over a 'distance'.<sup>1</sup>

In terms of its clinical applications, proponents view telemedicine as enhancing health care by: (1) providing care to distant underserved areas; (2) attracting patients living outside a hospital's catchment area; (3) optimizing the use of existing medical resources.<sup>1</sup>

Implicit in telemedicine's function of providing such 'distance' care, is also the notion of educating health care workers at a distant clinical site. Health professionals and trainees at such distant sites stand to benefit by participating via telecommunications with experts at tertiary centers in arriving at diagnoses and formulating treatment plans. Moreover, telemedicine can also be used specifically for didactic purposes in teaching medical students and residents working in distant health care locations. Continuing medical education for physicians working in rural areas is another educational application of telemedicine. Finally, telemedicine can also include the education of patients—not only in the

sense of providing specific patients with their diagnosis and treatment plan, but also more generally in educating the public at distant locations about health and preventive care.

Most studies on telemedicine have focused on its clinical applications rather than on its educational capacity. In this article, we will therefore focus on telemedicine's clinical applications specifically with reference to obstetric ultrasound. We suggest that, for less experienced health care workers and students, the process of participating with experts in such tele-health care sessions carries intrinsic educational value. Finally, we briefly discuss the specific application of telemedicine to medical education.

## TELEMEDICINE TECHNOLOGIES

Telemedicine technologies may be broadly divided into two categories: 'store-and-forward' and 'interactive'. *Store-and-forward* technology refers to a low cost method of first storing information on a computer before subsequently transmitting it to the relevant participants for analysis. The technology is often used by hospitals and clinics for storage and subsequent transmission for expert advice on pathology and radiology images. *Interactive* telemedicine entails face-to-face interaction either between health care professionals, or between health care professionals and the patient. This form of telemedicine may involve live videoconferencing

or phone conference calling to discuss internet-transmitted images.

Alternatively, telemedicine may be conceptualized as being either ‘synchronous’ or ‘asynchronous’.<sup>1</sup> *Synchronous* services occur in real time and are primarily used in situations where live interactive communication is needed. *Asynchronous* telecommunications are viewed at a different time to that of actual transmission and are used when the patient does not need to be present. Synchronous services utilize interactive telecommunications whereas asynchronous services utilize mostly store-and-forward communications. Many telecommunication programs offer both services and it is usually a matter of available facilities and judgment which of the technologies to use. Both technologies can be used for education.

For telemedicine to operate effectively, there must exist the technological capacity to transmit clearly and unambiguously between the participants in a patient’s care the critical elements of the clinical situation. Since this distance communication occurs without the immediacy of the usual face-to-face doctor-patient encounter (which allows for additional clarifications of communication) telecommunication must perforce place a priority on clear communication.<sup>1</sup> The technological capacity of telemedicine must include the transmission of clinical information of diagnostic quality and the ability of experts at tertiary facilities to respond unambiguously and in a timely fashion with a diagnosis and suggestions for treatment and subsequently, to communicate requests for additional information and inquiries about the patient’s changing condition.

Vast improvements have been seen in recent years in telecommunication and computing speeds and in storage capacities all of which have resulted in remarkable improvements in the quality and reliability of the communicated medical information. Whereas video-conferencing was initially most extensively used, various other modalities are now used (often simultaneously) including images, video, internet, voice transmission, computers, satellite transmission and fiber optics. Since the cost of implementing a telemedicine system is often a concern, several studies have analyzed the costs and benefits of implementing telemedicine systems.

## Benefits and Costs of Telemedicine

Among the advantages frequently cited in favor of telemedicine are the costs saved in unnecessary transfer of patients to tertiary centers for expert diagnosis and treatment. Another benefit of telemedicine is that it saves time by averting such unnecessary transfer of patients. Diagnoses can be obtained and treatment plans implemented in a shorter time and with less disruption. As a consequence, patients also report less stress and disruption to their work and family life. Even over relatively short distances telemedicine can save time and lives. Su et al (2008) describe how the use of tele-ultrasound in emergency medical services in Taiwan shortened by 3 hours the time between the arrival of a patient at the hospital and their entry to surgery.<sup>2</sup> They suggest therefore that the use teleultrasound may be well-suited for the management of high-risk pregnancy and complicated labor and delivery.

Several studies have examined the costs involved in updating telemedicine systems from traditional systems such as videotape review networks to systems based on modern telemedicine technologies. Malone et al (1998) reported that although substantial costs were associated with the initial purchase of telemedicine equipment for obstetric ultrasound (about \$25 0000 per site), these costs were offset by savings in nonfixed costs.<sup>3</sup> The authors examined the reasons as to why many obstetric centers still prefer to obtain hard copy ultrasound images. Reasons include: quality assurance, subsequent review, preservation in case of litigation, creation of an image bank for research and education. The authors point to the substantial costs accrued over time in producing and storing such hard copy images compared with the relatively inexpensive digitally stored telemedicine images which can also be instantaneously retrieved for review and transmission to other centers.

Anderson et al (2004) performed a study to demonstrate the benefits and cost savings of telemedicine in obstetric ultrasound applied in resource-poor settings. The authors stress that in resource poor settings costs for transport to tertiary health centers (in rural East Texas) present a substantial burden on monthly salary (9%) and that telemedicine offers a major cost saving when patients can avoid travel.<sup>4</sup> Many patients miss appointments rather than

<sup>1</sup>In this regard, the impact on telemedicine on the patient-doctor relationship has been raised as a concern since the patient no longer has the experience of being in the presence of the physician and may as a consequence feel somewhat disconnected from the clinical encounter.

undertake costly travel and disruption and this likely exerts a negative impact on their health outcomes.

A more recent study in the United Kingdom analyzed the costs of introducing a telecardiology service between specialists in London and district hospitals in south-east England for screening of fetal heart anomalies in second trimester pregnant women.<sup>5</sup> The study found that telemedicine assessments of only 5 minutes duration were initially more costly than direct assessments by cardiologists at tertiary centers in London, but that after a period of fourteen days from the time the service was provided (and for the rest of the pregnancy period until delivery) the telemedicine service was cost neutral. The authors conclude that establishing such telemedicine networks between specialist centers and referring district hospitals is an efficient and economic way of providing support to local obstetric screening programs and could avoid unnecessary referral to tertiary centers.

### WHO USES TELEMEDICINE?

A study in the remote Magdalene Islands, an archipelago in Canada's Gulf of St Lawrence, also demonstrated the efficacy of telemedicine in averting unnecessary medical transfers but, furthermore, discovered that utilization rates among physicians were not as high as expected mostly because physicians claimed they had not thought of using the service.<sup>6</sup> Educating physicians as to the availability and efficacy of telemedicine thus seems an important priority. Regular and routine, rather than sporadic, use of telemedicine has been found to be important for the ongoing success of telemedicine projects.<sup>7,8</sup> Another factor that determines whether physicians will use a telemedicine service, according to Tanriverdi and Venkatramen,(1999), lies in the reputation of participating expert physicians.<sup>8</sup>

Hu et al (2000) stress that implementation of telemedicine systems also depends on integrated organizational variables.<sup>9</sup> For instance, the implementation of the Magdalene Island telemedicine project was greatly facilitated by the presence of key individuals in strategic positions at different levels in the organization.<sup>6</sup> The authors of the Magdalene Islands study caution that effective deployment of telemedicine in a health care system requires a structured and carefully considered approach.<sup>6</sup> Education of health care workers and students in the effective utilization of telemedicine may therefore be an important adjunct to its direct application in patient care.

Less expectedly, in Australia Woodrow et al (1998) showed that telemedicine could avert litigation.<sup>10</sup> A large proportion of litigation problems associated with antenatal ultrasound were due to the patient not being referred in time to the appropriate tertiary referral center – a problem which the application of telemedicine might have averted.

### APPLICATION OF TELEMEDICINE TO OB/GYN

Teleradiology has been studied for about 40 years, but it has only more recently been applied to the field of obstetric ultrasonography. In 1997 Landwehr and colleagues showed that telesonography could be a useful clinical tool for remote interpretation of fetal ultrasonographic images.<sup>11</sup> Malone et al (1997) showed that transmission of such obstetric ultrasonographic images via satellite and ISDN (integrated services digital network) was feasible especially for interpretation of fetal anatomy in low risk populations, and that the technology was comparable in standard to videotape review.<sup>12</sup>

Nonetheless, the benefits of routine ultrasonography in low-risk populations remains debatable<sup>13,14</sup> even if its applications have been well-established in high-risk populations.<sup>15</sup> One of the reasons for the controversy appears to be the variation in sonographic standards between different centers. For instance, nontertiary centers are known to have a lower rate of detection of fetal anomalies compared to tertiary centers.<sup>16</sup> To expect all pregnant women to present to a tertiary level pregnancy facility for obstetric sonography is, however, impractical. Telemedicine offers the possibility of providing expert sonographic interpretation and diagnosis from tertiary centers to less experienced clinical centers or local physician's offices, thereby obviating the need for pregnant women to be seen at tertiary centers.

The question arises as to which obstetric clinical scenarios should be referred for real time ultrasound telemedicine consultation. In a study on the clinical value of real-time tertiary fetal ultrasound consultation in telemedicine, Chan et al. (2000) suggested the following indications for telemedicine referral: (1) third trimester assessment of growth restriction/fetal well-being; (2) high-risk patients requiring detailed assessment; (3) evaluation of markers for anomalies; (4) isolated fetal anomalies; (5) complex fetal issues such as twin-twin transfusion, multiple anomalies and others.<sup>17</sup> Overall they found diagnostic variation occurred in 4% of patients and that there was a 33% variation in management decisions. The majority of the diagnostic

variations were minor, and the variations in management related mostly to decisions about the physical transfer of patients and minor variations related to the frequency of clinical monitoring.

A study conducted in a Newfoundland, Canada, to evaluate the efficacy and reliability of tele-obstetric ultrasound services delivered from an urban tertiary care center to a remote hospital concluded that telemedicine services using conventional analog telephone lines was feasible.<sup>18</sup> The study found that, compared to a control group of patients who traveled to a tertiary center hospital for direct radiologic examination, telemedicine systems shortened the time it took to be informed of results by an average of one week. This study therefore demonstrated that there are alternatives to expensive high-speed communication telemedicine systems and that in rural regions that lack such costly systems, analog transmission via telephone lines could be used.

## TELEMEDICINE AND MEDICAL EDUCATION

There are few published studies on the value of tele-obstetric ultrasound in medical education. Nonetheless, the potential of telemedicine as a tool in medical education should be self-evident. Tele-health care provided by experts at tertiary centers carries intrinsic education value for less experienced participants at distant locations who benefit by following the diagnostic reasoning and formulation of treatment plans of expert physicians.

But telemedicine can clearly also be utilized specifically for educative purposes. Besides the educational value of still images, lectures and course content transmitted via internet, the videoconferencing of seminars, workshops and one-on-one teaching are also readily available today at a fraction of previous costs. Both 'synchronous and 'asynchronous' telemedicine technologies can be used for education. These technologies are readily adaptable for education in various fields of medicine including obstetric ultrasound.

A study conducted in Vermont illustrated the use of telemedicine in continuing medical education (CME). The study delivered CME via a telemedicine network to 14 hospitals in Vermont and in rural northeastern New York, and compared the evaluative responses of those receiving the CME via telemedicine with those attending in person at the CME event.<sup>19</sup> The responses of 650 attendees at both telemedicine-transmitted CME events and CME events

attended in person (over a 3 year period) indicated that telemedicine-transmitted CME was considered (79% of the time) at least as effective as CME attended in-person. Even though in-person attendance received overall high quality ratings, the study indicates the telemedicine CME is feasible and quite effective. The study also showed that for 82% of the attendees CME was delivered where it would otherwise not have been delivered, and that travel was averted for 18% of the remote attendees.

## CONCLUSION

In brief, telemedicine is an evolving technology that has been shown to be critical in the delivery of expert care to patients at distant locations. In addition, it performs a vital role in the education of health care workers at such locations. Although as yet not specifically investigated, the potential of telemedicine in teaching Obstetrics and Gynecological ultrasound to medical students should be evident.

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