Telephonic transmission of cardiotocographic recordings from a remote facility to an obstetric unit

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Summary: The Authors describe their experience in telephonic transmission of cardiotocographic recordings. With a Corometrics 116 and 410 unit installed in a remote facility, 61 CTG recordings were tele-transmitted and received by a Toshiba personal computer. The concordance between original and transmitted CTG record was excellent and a very low percentage of signal loss during transmission (3.2%) was found. The advantages of telephone transmission of CTG in peripheral areas are stressed.

INTRODUCTION

The Italian Health Service has identified the districts as the social facilities to be charged with the servicing of a specific territorial area having a population fluctuating between 10,000 and 20,000 units. The aim of our experimental contribution was to verify the possibility of a connection between the hospital centre and the district facilities in order to carry out and transmit the cardiotocographic graph during pregnancy. This choice was made, on the one hand, in order to foster the decentralization of the sanitary services, of which the pregnant woman can avail herself, and on the other hand, in accordance with the need to stimulate the paramedical personnel and the obstetricians of the district, to re-establish their role as far as pregnancy control is concerned, and to act as intermediaries between the single patient and the facilities within the hospital centre.

From a technical point of view, the possibility of transmitting the cardiotocography by telephone has increasingly become more concrete due to the use of new cardiotocographs having a serial output RS 232. The digitized signal can easily be transmitted through both modem and telephone line from a distant user to a listening and recording centre. The first description of a distance cardiotocographic transmission ([3]) is linked to the use of a prenatal monitoring system of the fetal heart rate through telemetry. In this experiment 20 telecardiograms were recorded on 11 patients starting from the sixteenth week up to the end of pregnancy. By positioning the telephone receiver in such a way that its microphone was close to the loudspreaker of the tracer, the fetal heart signal was sent in real time through the

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telephone line from the patient's residence to the hospital. Once the signal was on its way to the obstetrics unit it was conveyed through a preprocessor and subsequently through a Hewlett Packard 9826 (or HP 9825) computer with the programme HPL Teleplot. The average heart rate was calculated every 3.7 seconds (1/16 of a minute) and constantly displayed on a screen in a way mostly indistinguishable if compared to the ordinary graphs on paper. The signal loss between the original recorded graph and the one transmitted as the qualitative index of the transmission was calculated: in some cases it was above 53%. Lindsay ([10]) describes the results obtained on 858 graphs concerning 134 patients: all the recordings were transmitted by telemetry from the residence of the patient. In 5.2% of the cases the execution of a conventional recording was made necessary because of a dubious distance recording. In 16% of the cases an obstetrical intervention was made necessary. In another experiment ([8]) a digital system was developed for the immediate transmission of the compressed data. The data of the fetal cardiac frequency (FCF) were conveyed and compressed in real time by the recording unit at the patient's residence. During a period of about four years 1120 graphs concerning 74 patients were transmitted: 55% of these were recorded by the obstetricians, 45% by the patients themselves. The signal loss was below 1%. The system has allowed the successful intervention in emergency with 3 patients because of the recording of low variability with decelerations in the FCF. Such data were confirmed by the conventional monitoring before childbirth. All the remaining patients avoided hospitalization and frequent waits in the clinic.

SUBJECTS AND METHODS

To support our experiment a system of transmission of the distance cardiotocography was developed. It was made up of:

– peripheral centre: a cardiotocograph Corometrics 116 combined with a storage and alarm unit 410; a modem connected with the serial output of the unit 410 with transmission at 1200 and 2400 Baud;

– main centre: receiving system with personal computer Toshiba with hard disk of 20 Mb with modem card incorporated with software Spectra-Tel. The recording station was positioned in a peripheral advisory bureau, 22 km away from the Hospital centre, situated in an unfavourable hilly area, which was possible to reach only by means of one very winding road and as a result had poor public transport.

The signal of the FCF shown by the Corometrics 116 was processed by the unit 410: the latter has two fundamental characteristics, i.e. of storing up to 120 minutes of cardiotocographic recording, and also of using a series of alarm filters (Table 1). The latter is shown on the computer screen at the moment of distance transmission with three different levels of gravity. The patient, in the half-seated position, was carrying out the cardiotocographic recording lasting at least 30 minutes which was being conveyed in the storage of the unit 410.

The recordings was simultaneously carried out on paper by the cardiotocograph and made available for documentation in the peripheral centre. As soon as the recorded graph was considered sufficient it was transmitted to the centre via modem. The personnel at the centre could visualize both the trend of the graph and the eventual presence of alarm signals of different gravity. The transmission took place within relatively short times (1′-1′30″ for a 30′ graph); after the reception of the recorded graph the computer automatically positioned itself for reception in real time.

In such a way the recording of the frequency could take place simultaneously on both the cardiotocographic graph in the peripheral centre and on the screen of the computer in the main centre. For obvious reasons i.e. cheapness, practicality and engagement of telephone lines, we preferred to work by transmitting graphs at the end of their recording rather than in real time. At the end of each transmission we took note of the reading capacity of the used solftware and of the quality of the transmitted signal. Then we compared the visual reading with the distance reading of the graph itself in order to verify the reliability of the recording carried out with the patient in the peripheral centre.

RESULTS

53 patients were assisted with this method. The average duration of the recording was 38.5 ± 12.1 minutes. Table 2

Table 1. – *Alarm levels unit corometrics 410.*

LEVEL 1
- Reduced variability
- Absence of variability
- Slight bradycardia (100-119 bpm)
- Slight tachycardia (161-180 bpm)
- Slight/medium variable decelerations
- Slight/medium sporadic decelerations
- Non classifiable decelerations
- Prolonged decelerations with slight bradycardia (120 bpm) and reduced variability
- Uterine hypertone
- Tetanic contractions (60 sec.)

LEVEL 2
- Tachycardia (180 bpm)
- Bradycardia (90-99 bpm)
- Belated decelerations
- Serious variable decelerations or sporadic decelerations
- Tachycardia with absence of variability
- Mixed decelerations
- Belated slight decelerations or mixed with reduced variability
- Slight variable decelerations with absence of variability
- Prolonged decelerations (80-119 bpm)

LEVEL 3
- Bradycardia (90 bpm)
- Prolonged decelerations (80 bpm)
- Belated variable decelerations or mixed with reduced variability and tachycardia or bradycardia
- Serious belated or variable decelerations with tachycardia or bradycardia or reduced variability
- Serious belated variable decelerations with tetanic uterine contractions.

briefly shows the characteristics of the patients examined for this study. They were characterized by the absence of risk elements in pregnancy (62.2% of the cases); other patients had conditions of increased uterine contractile activity which the table shows as a threat to premature delivery (15.0%); in 13.2% of the cases it was shown that the cardiotocopraghy was linked to pregnancy beyond term (between 40 and 42 weeks). Our sample also includes a small number of patients with glycometabolic problems (5.6%) and of patients with pregnancy hypertension (3.7%).

Table 2. – *Telecardiotocography: characteristics of the examined sample risk elements in pregnancy.*

	No.	%
Absent	33	62.2
Threat of premature delivery	8	15.0
Pregnancy beyond term	7	13.2
Gestational hypertension	2	3.7
Impaired OGTT	3	5.6

Gestational AGE 32-41 weeks.

The gestational age during which the recordings have been carried out is between 32 and 41 weeks of pregnancy.

The total number of the examined graphs is 61. Table 2 shows the results concerning the comparison between the reading of the original cardiotocography and the reading of the graph recorded either on the screen or on the computer printer. For this purpose both the original graphs and the transmitted ones were read by two operators independently.

The reading of the peripheral graph was superimposed uniformly upon the reading of the original graph which identified correctly both the reactive and the non-reactive graphs, the episodes of bradycardia and those of tachycardia, the decelerations and the variability below 5 beats per minute (bpm).

It is interesting to point out that in the situations on the peripherally transmitted graph there was a signal loss.

This one was very often ascribed to an incorrect recording of the initial signal, and not to poor quality transmission of the datum along the telephone line. We wanted to verify how reliable the graph valuation software was, when it was lin-

Table 3. – *Comparison reading of the cardiotocogram original graph/teletransmitted graph.*

	Original CTG	teletransmitted CTG
Reactive CTG	60	60
Non reactive CTG	1	1
Bradycardia	1	1
Tachycardia	1	1
Decelerations	1	1
Variability below 5 BPM	2	2
% scarce quality signal	3.27%	3.27%
Concordance	61/61	100%
Non concordance	–	0%

Table 4. – *Comparison reading of the cardiotocogram visual reading/computerized reading.*

	Visual reading	Computerized reading
Reactive CTG	60	non pointed out
Non reactive CTG	1	non pointed out
Bradycardia	1	1
Tachycardia	1	1
Decelerations	1	9
Variability 5 BPM	2	–
% scarce quality signal	3.27%	6.55%
Concordance	48/61	78.6%
Non concordance (*)	13/61	21.3%

(*) In eight graph the non concordance refers to the basal FCF and the decelerations.

ked to the system 410. From the analysis of the table it is emphasized how the valuation of a reactive or non-reactive graph is not reported by the software, reducing the possibility of judgement on the value of the graph itself.

It was possible to point out a discordance in the identification of some recorded cardiotocographic patterns. In particular, the decelerations observed in one single occasion through the visual reading are identified in at least nine cases in the computerized reading. Similarly, the quality of the signal is judged poor in 6.45% of the cases.

The data exposed in this way are summarized by the expression concordance or non-concordance between the visual reading of the original graph, the visual reading of the transmitted graph and the computerized reading of the transmitted graph (Table 3 and 4). It is to be pointed out how in the first case we are faced with a concordance of 100%, whereas between the visual reading of the original graph and the isolated reading of the computerized graph there is a discrepancy which is above 20%.

DISCUSSION AND CONCLUSIONS

The conventional monitoring technique of the fetal cardiac rate is well known and it represents the more frequently used technique of fetal watch.

The aim of the fetal home monitoring recordings is not that of supplying something different from what is already available with the conventional cardiotocography. The home fetal monitoring is to be conceived as a technique of screening which can be carried out with a certain repetitiveness, but with the least inconvenience to the patient and to the working perinatal unit.

In particular, the extension of perinatal obstetrical control is addressed to a well determined sample of patients.

As a matter of fact, the users of this methodology are those patients whose present conditions are not so serious that they require hospitalization, but neither are these conditions to optimal that the patients can put off the periodical control of the FCF.

From the point of view of a health planning the development of a fetal monitoring system presents three points of undisputed advantage:

a) A reduction in hospitalization time and in hospital costs for those patients

who belong to an average risk strata, and who can keep in touch with the reference centre through this system so that they do not occupy a bed, but rather stay at home;

b) The reduction of the inconvenience caused by the patient's continual transfer from her own home to the reference centre;

c) The revival of the peripheral districts which, connected on line with the centre, assume real importance as first territorial health services and not merely entities of low quality technology and experience as, unfortunately, they are often considered by the users of today.

In previous experiments the implications connected with the technical problem of the equipment used and with the human problem, concerning both the patients and the personnel, have been fully described. In short, the teletransmission of the cardiotocography implies: an excellent acceptance on the part of the patients, but also difficulties in serving a high number of users with home stationing; an excellent acceptance on the part of the obstetric and all paramedical personnel at the periphery, and good acceptance on the part of the hospital personnel who therefore have a reduced burden of direct work. The experiment we carried out is different from those reported in previous literature as far as the location of the cardiotocograph is concerned: the choice not to take it to the patient's residence, but rather to locate it within a territorial health district, solves many of the problems pointed out by many previous Authors, and it allows for optimum work by the paramedical personnel in the districts, guaranteeing a multipicity of access to the equipment which serves a greater number of pregnant patients. In the sample that we examined there is a percentage of patients (37.8%), who would have needed either to undergo the recording in the Hospital or to be hospitalized for the carrying out of the recording itself. It is important to point out how even though patients with low or with no pregnancy risk (62.2%), would have had to go to the hospital cardiotocographic centre.

The recording of the cardiac frequency carried out in such a way led to a subsequent hospital control for those cases which had decelerations and increased contractile activity in premature pregnancy times. The comparison concerning the visual reading of the original graph and the reading of the graph transmitted by the centre was optimal: an experienced operator cannot find any difference between the parameters recorded on the original cardiotocogram and those recorded on the printer and on the computer. On the contrary, the reading entrusted exclusively to the computerized system does not allow us to express the result satisfactorily since a non-concordance of 20% more than the recorded graphs was pointed out, along with an absence of identification of some parameters of great importance such as the accelerations and the variability trend. From a technical point of view, however, the system can work validly if the reading is carried out by an experienced doctor at the reference centre.

In the future of the perinatal health service this technological support can play an important role in the decentralization of the biophysics diagnostics of the last quarter of pregnancy, and in the connection of smaller centres with reference centres having greater perinatological experience.

REFERENCES

1) Baskett T. F., Gray J. H., Prewett S. J. *et al.*: "Antepartum fetal assessment uring a fetal biophysical profile score". *Am. J. Obst. Gyn.,* 148, 1984.
2) Brown R., Patrick J.: "The non stress test: how long is enough?". *Am. J. Obst. Gyn.,* 141, 1981.
3) Dalton K. J., Dawson A. J., Gough N.A.J.: "Long distance telemetry of fetal heart rate

from patients own home using telephone network". *Br. Med. J.,* 286, 1983.

4) Dawes G. S., Visser G. H. A., Goddman J. D. S., Redman C. W. G.: "Numerical analysis of the uman fetal hearth rate: the quality of ultrasound records". *Am. J. Obst. Gyn., 89,* 43, 1981.
5) Dawson A. J., Middlemis C., Jones E. M., Cough N.A.L.: "Fetal heart rate monitoring by telephone. I. Development of an integrated system in Cardiff". *Br. J. Obst. Gyn., 95,* 1018, 1988.
6) Flynn A. M., Kelly J.: "Evaluation of fetal well-being by antepartum fetal heart rate monitoring". *Br. Med. J., 1,* 936, 1977.
7) Flynn A. M., Kelly J., Mansfield H., Needham P., O'Connor M., Viegas O.: "A randomised controlled trial of non-stress antepartum cardiotocography". *Br. J. Obst. Gyn., 89,* 427, 1982.
8) Gough N. A.L., Dawson A. J., Tomkins T. J.: "Antenatal fetal heart rate recording and subsequent fast trasmission by a distributed microprocessor-based system". *Int. J. Biomed. Comp., 18,* 61, 1986.
9) James D., Peralta B., Porter S. *et al.,*: "Fetal heart rate monitoring by telephone. II Clinical experience in four centres with a commercially produced system". *Br. J. Obst. Gyn., 96,* 1024, 1988.
10) Lindsay P. C., M. A., and A.: "Patient recorded domiciliary fetal monitoring". *Am. J. Obst. Gyn., 162,* 466, 1990.
11) Lumley J., Lisster A., Anderson I., Renou P., Wood C.: "A randomised trial of weekly cardiotocography in high risk obstetric patients". *Br. J. Obst. Gyn., 90,* 1016, 1983.
12) Visser G. H. A., Redman C. W. G., Hcisjes H. J., and Turnbul A. C.: "Nonstressed antepartum heart rate monitoring. Implication of acceleratio after spontaneus contraction". *Am. J. Obst. Gyn., 138,* 429, 1980.

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