5-1-1977

An outpatient environment for fetal monitoring

Claude Hutcheson Jr

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ROCHESTER INSTITUTE OF TECHNOLOGY

AN OUTPATIENT ENVIRONMENT FOR FETAL MONITORING

A THESIS SUBMITTED TO
THE FACULTY OF THE COLLEGE OF FINE AND APPLIED ARTS

DEPARTMENT OF ENVIRONMENTAL DESIGN

BY
CLAUDE HILLYER HUTCHESON, JR.

ROCHESTER, NEW YORK
MAY 1977
<table>
<thead>
<tr>
<th>CONTENTS</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ILLUSTRATIONS</td>
<td>iv</td>
</tr>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>v</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>PURPOSE AND SCOPE</td>
<td>3</td>
</tr>
<tr>
<td>FETAL MONITORING</td>
<td>5</td>
</tr>
<tr>
<td>DATA GATHERING</td>
<td>11</td>
</tr>
<tr>
<td>DESIGN DEVELOPMENT</td>
<td>31</td>
</tr>
<tr>
<td>SYSTEM DESCRIPTION</td>
<td>56</td>
</tr>
<tr>
<td>APPENDIX A</td>
<td>79</td>
</tr>
<tr>
<td>APPENDIX B</td>
<td>88</td>
</tr>
<tr>
<td>SELECTED BIBLIOGRAPHY</td>
<td>89</td>
</tr>
</tbody>
</table>
ILLUSTRATIONS

1. Design Plan ........................................... 2
2. Fetal Heart Rate and Maternal Contraction Chart .......... 8
3. Three Major Patterns of Fetal Heart Rate Deceleration ... 8
4. Abdominal Lead Placement ................................ 10
5.-7. Existing OCT Laboratory ................................ 12-14
8.-13. OCT Operation Cycle .................................. 17-22
14. Summation OCT Operation Cycle .......................... 23
15. Flow Diagram ............................................ 24
16. Anthropometric Measures .................................. 26
17.-18. Seating Criteria ...................................... 27-28
19. Patient Support Measures .................................. 29
20. Layout Studies ............................................ 36
21.-39. Concept Sketches ..................................... 37-55
40. Outpatient Environment for Fetal Monitoring .......... 63
41. Arrangements ............................................. 64
42. Model ..................................................... 65
43. Plan View of the Outpatient Environment ............... 66
44.-45. Model .................................................. 67-68
46.-49. The Fetal Heart Rate Monitor ......................... 69-72
50.-52. The Patient Support ................................... 73-75
53. The IV Module ........................................... 76
54. The Display Unit ......................................... 77
55. The Future ............................................... 78
ACKNOWLEDGMENTS

The author is indebted to a number of people for assistance and advice in the conduct of the studies leading to the designs presented in this paper. I would like to thank them.

At Rochester Institute of Technology: Craig McArt, Toby Thompson, and special thanks to James Hennessey, who was my chief advisor.

At Strong Memorial Hospital: Dr. Harold Fox, my associate advisor who found time in a busy schedule to answer numerous questions on fetal monitoring and helped me to define the scope of this project, Len Braun, Nancy Peco, and Catherine Petocchi.

I would also like to thank my wife, Bobbie, for her patience and understanding.
INTRODUCTION

In considering several areas of interest, which would offer fertile ground for design exploration, I was attracted to the recent developments in the field of perinatal medicine; in particular, that of fetal monitoring.

My interest stemmed from the fact that fetal monitoring is conducted in the hospital setting and involves unique procedures; however, it differs from the majority of hospital services in that the patient is not necessarily ill, but rather, is there in order to determine the status and well being of the fetus. The area in which this test is conducted should be an efficient and pleasant environment for both the patient and the medical staff.

On visiting the department of Obstetrics-Gynecology at Strong Memorial Hospital, I was referred to Dr. Harold Fox in the perinatal unit. It was in this and several subsequent discussions with Dr. Fox that the boundaries of the project began to take form and a design plan (see fig. 1) was established which ultimately led to the design proposals which constitute this thesis.
design plan

Fig. 1. Design plan
PURPOSE AND SCOPE

The purpose of this thesis is twofold. First, to design a fetal monitoring system, based on current ultrasonic monitoring technology, which would improve the user/machine interface and would enhance the monitoring environment, hopefully, increasing patient acceptance. Secondly, to serve as a medium in which the designer may gain insight into the design of medical instrumentation and increased awareness of the factors involved in designing for the hospital environment.

The scope of this project encompasses designs for the outpatient fetal monitoring area, the patient support (bed), intravenous (IV) support module, and a fetal monitor which had to have the capability of being used in the labor and delivery areas as well as in the outpatient test area. In addition, the design process resulted in the proposal of an optional patient display unit for presenting educational or entertaining material during patient monitoring.

It should be emphasized that the designs resulting from this work should be considered as proposals only. Although the research and development which went into this work was as extensive as time would allow, considerably more time would be required to reduce these designs to hardware. In addition, human factors testing of prototypes would be required to assure that patient comfort and safety as well as operator/therapist convenience goals have been met. Although it was not possible, due to the nature
of this project, to have a human factors engineer participate in the design process, further development of the devices proposed here should include this discipline, working in conjunction with the designer. In this thesis the designer has attempted to conduct the anthropometric and space layout studies necessary and sufficient to define a functional fetal monitoring environment.

Underlying this thesis are several assumptions: (1) that fetal monitoring by ultrasound is safe; (2) that Oxytocin Challenge Test (OCT) outpatient centers will increase in number, making designs unique to this procedure viable; and (3) that the fetal monitoring environment should be visually and kinesthetically pleasing, yet possess emotive qualities which convey accuracy, safety, cleanliness, efficiency, etc.

The logotype shown on the entry wall of the monitoring environment (fig. 40) was derived by the designer in the course of this study, as an abstraction of the concept of growth, or cell division. It is rendered in a vivid green to connote life, or living, which the designer feels is appropriate for use in fetal monitoring. This is purely subjective, however, and has not been confirmed by behavioral testing.
FETAL MONITORING

The fetal heart is an excellent source of information about the status of the unborn. It has the advantage of being readily available through such monitoring means as phonocardiography, electrocardiography, and ultrasound. According to Curran, "The detection of the fetal heart by ultrasound, either continuous or pulsed, is the most reliable method at any stage of pregnancy." This project is based on the use of continuous Doppler ultrasound as used in outpatient testing.

Fetal distress is a condition of the fetus brought about by a failure of the oxygen supply to the brain and ultimately results in spasticity, a reduction in mental health, or death. Monitoring the fetal heart rate provides valuable data which can be analyzed to detect and avert fetal distress.

---


2 J.T. Curran, (p.26), cites L.W. Cox et al., *Lancet* 1 (1963): 841, in outlining the correlation between fetal heart rate changes in labor and final outcome:

"1. A mild anoxia causes a compensatory increase in heart rate in an effort to maintain the oxygen supply.
"2. Further anoxia irritates the vagal centre and causes a slowing of the heart rate.
"3. Severe anoxia affects the heart muscle itself with resulting bradycardia and irregularity.
"4. Total anoxia leads to death."
The fetal monitor as used in the outpatient OCT laboratory and in the labor room employs the indirect (non-invasive) method whereby a tocodynamometer—to measure uterine pressure—and a crystal transducer—to monitor fetal heart rate—are secured to the maternal abdomen with tape or an elastic retainer. Alternately, when the monitor is used in the delivery room the direct (invasive) method is used. In this instance, fetal heart rate is derived from the fetal ECG. These signals are directly obtained by using a small, specially designed electrode (with the membranes ruptured and the cervix dilated at least 2 to 3 centimeters and the presenting part accessible), which is attached to the presenting part of the fetus. Uterine contractions are measured using an intrauterine catheter.

The Oxytocin Challenge Test is conducted in the third trimester of pregnancy and is normally scheduled on an outpatient basis. Although this test is usually indicated for women who have a history of problems with pregnancy or complicating conditions such as high blood pressure or diabetes, it is available to others. The test, according to Gholamali Farahani et al., "... attempts to duplicate the stresses of labor by induced contractions and observance of the fetal heart response so that placental reserve or fetal welfare can be evaluated."3 The data resulting from the OCT gives the physician information on which to base his decisions and advice to the patient.

3Gholamali Farahani et al., Obstetrics and Gynecology 47 (February 1976): 159-60.
Data from the fetal heart monitor are recorded on a paper chart with the fetal heart rate tracing (beats per minute) above the contraction curve (see fig. 2). Data from fetal heart responses to contractions have been analyzed and various patterns classified. Although there is no one standard method of classification, several reports suggest classification criteria. The illustration in figure 3 gives an overview of fetal heart rate deceleration patterns.

Indirect fetal monitoring by continuous Doppler ultrasound, unlike fetal phonocardiography and fetal electrocardiography, is an active system. Energy in the form of sound waves (2 mHz), generated by a vibrating crystal, is transmitted via crystal transducer positioned on the maternal abdomen. These waves are capable of penetrating biological tissue; however, some of the energy is reflected at each interface. The ultrasonic Doppler device detects moving surfaces within the body by measuring the frequency shift of the ultrasonic beam as it is reflected from these surfaces. If the frequency of the reflected wave is compared with the frequency of the original, the difference in the two frequencies will be related to the speed at which the reflector is moving. The reflected wave is detected by a second crystal, which is located beside the transmitting crystal, in the transducer. The greater the frequency shift, the higher the output on the chart. It is necessary that the movement of the surface be at right angles to the ultrasonic beam. Ultrasound is poorly transmitted through air, which makes it necessary to apply a gel to the transducer to act as a medium between it and the maternal abdomen. Although it is possible to obtain signals from numerous surfaces, both fetal and maternal, it is best to attempt to detect the movement of the cusps of the fetal mitral valve. This
Fig. 2. Fetal heart rate and maternal contraction chart

HEAD COMPRESSION
- UNIFORM SHAPE
  - 180 FHR
  - 180 EARLY ONSET
  - EARLY ONSET
  - EARLY ONSET
  - EARLY DECELERATION (HC)

UTEROPLACENTAL INSUFFICIENCY
- UNIFORM SHAPE
  - 180
  - 100 LATE ONSET
  - LATE ONSET
  - LATE DECELERATION (UPI)

UMBILICAL CORD COMPRESSION
- VARIABLE SHAPE
  - 180
  - 100 VARIABLE ONSET
  - VARIABLE ONSET
  - VARIABLE DECELERATION (CC)

Fig. 3. Three major patterns of fetal heart rate deceleration.
movement is sudden and produces a sharp click, which is suitable for rate counting.  

Experience makes it possible to locate the fetal heart and properly position the transducer; however, in the beginning, scanning with a routine search pattern to examine each quadrant of the abdomen is recommended. The transducer is held in place with an elastic belt, or in the case of the Strong Memorial OCT procedure, with a band of tube-o-grip, sufficient to cover the abdomen, which the patient slips on. This makes it possible to readily change the position of the transducer as well as the tocodynamometer (see fig. 4). Any movement of the patient or the fetus during monitoring produces an artifact which must be discounted in analyzing the tracing of the fetal heart rate. Spurious electronic signals are identified as artifacts by an indicator light; the recording of these must also be discounted. Artifacts and fetal or maternal movements are noted by the therapist, on the chart.

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4Curran, Fetal Heart Monitoring, p. 91.
Fig. 4. Abdominal lead placement
DATA GATHERING

With the completion of the project design plan and proposal acceptance, the data gathering phase of the design process was begun. Interviews were scheduled with the perinatal staff and the facilities were visited. Photographs were taken of the delivery room, labor rooms, and the OCT laboratory. Figure 5 shows the existing OCT laboratory. The IV pump and supply at the left of the bed is shown in figure 6. Figure 7 shows the existing room layout.

During the data gathering phase, a library search was conducted to research both delivery and fetal monitoring. Numerous journals available from the library and also several provided by Dr. Fox were reviewed. These are listed in the bibliography of this paper. In addition to journal review, a textbook of obstetrics provided by Dr. Fox was reviewed in order to gain an overview of this branch of medicine. Particular emphasis was placed on prenatal care and delivery. Relevant sections of both this text as well as pertinent journal articles were copied and organized so as to be readily available for reference later in the design process.

In attempting to gain an overview of prenatal care and child birth, not only of the technical aspects but also from the point of view of the mother-to-be, several books on the subject, found in
Fig. 6. Existing OCT Laboratory
local book stores and two television programs on childbirth were reviewed. In addition, a seminar on the use of ultrasonics in medicine, held at Rochester Institute of Technology, was attended and a tape was made of Dr. Charma's lecture on the use of ultrasound in obstetrics. Although her lecture centered around B-scan ultrasound and the interpretation of the various graph scans, she did give an interesting review of the technique of moving the transducer in order to properly locate the fetal heart.

The operation of the fetal monitoring hardware was reviewed and basic operator tasks defined (see appendix A). Len Braun, who is responsible for the maintenance of the electronic equipment for the perinatal unit was interviewed. Two monitors, the Fetasonde 2100 manufactured by the Medical Electronics Division of Hoffmann-La Roche, and the Brattle Fetal Monitor by B-D Electodyne were examined. Operator manuals were studied and component volumes identified (see appendix B).

Using these task outlines, the operator/machine interface was defined. It was during this phase in the design process that the designer sat in on an Oxytocin Challenge Test. Each procedure was noted and the movement of the therapist in the OCT laboratory in administering the test was documented. The resulting operation sequence diagram is shown in figures 8-14. These charts show the specific tasks which the therapist carries out and the actions required of the patient at each phase of the test. The location in the laboratory at which these tasks were carried out are also shown. The final chart (fig. 14) gives the summation of the movements required of the therapist and patient. These were translated into a flow diagram indicating the patient movement (in blue), and the therapist movement (in red) throughout the test. These are shown in figure 15, superimposed on the plan view of the existing OCT
laboratory. The width of the interconnecting lines in the chart is directly related to the extent of movement between positions. It should be noted, however, that this gives only a general picture of the monitoring procedure in the OCT laboratory because the tests will vary somewhat from patient to patient depending on the time taken to bring the contractions up to the desired intensity and frequency, as well as the difficulty in locating and maintaining the fetal heart rate.

Additional observations were made, such as the body positioning required of the therapist to gain access to the patient and equipment. Of particular concern was the posture of the therapist, which seemed strained in viewing the OCT chart. The chart exits the monitor in a vertical position which requires the therapist to turn her head ninety degrees from the vertical or to hold the chart out from the monitor to properly view the data. In addition, since numerous notes are added to the chart to indicate fetal movement, maternal movement, artifacts, blood pressure (every 10 min.), as well as the starting and stopping of the pitocin IV, the therapist is frequently required to mark the chart. This must be done by writing on a vertical, rather than horizontal, plane. Movements required of the patient, such as entering and exiting the bed, were also noted so that design criteria could be established.

Anthropometric data around which to base the design of the patient support were obtained primarily from two sources. The measures shown in figure 16 were derived from studies conducted by Clauser on Air Force Women.\footnote{Charles E. Clauser, \textit{Anthropometry of Air Force Women}, (Ohio: AD 743 113, 1972), pp.74-112 passim.} Abdominal measures were obtained from Dreyfuss; however, no specific data on pregnant
Fig. 8.

PATIENT

ENTERS/FAMILIARIZATION

DOFFS SELECTED CLOTHING

SLIPS ON TUBE SUPPORT

ENTERS BED

THERAPIST

INITIAL EQUIPMENT SETUP

INSTRUCTS

ASSISTS IN TUBE DONNING

ADJUSTS BED IF REQUIRED

GETS ALCOHOL FROM STORAGE

PREPARES ABDOMEN

WIPE SELECTED AREA, DISPOSE

OCT OPERATION CYCLE

ENTRY

BED/LS

BED/RS

MON

AI

DISPOSE

SUPPLY

DESK
Fig. 9.

PATIENT

PLACES GEL ON TRANSDUCER
PLACES TRANSDUCER ON ABDOMEN
ADJUST RANGE CONTROL
PLACE TOCO DYNOMETER
ADJUSTS BASELINE TO "0"
READIES ARM FOR BP

THERAPIST

TAKES BP
STARTS IV/BUTTERFLY/HAND
CUT IN PITOLIN/SET 3cc/MIN.
PRESSES "ON"
PRESSES "START"

OCT OPERATION CYCLE
ENTRY
BED/LS
BED/RS
MON
IV
DISPOSE
SUPPLY
DESK
Fig. 10.

PATIENT
- PATIENT RELAXES
- MAY LISTEN TO FHR AUDIO
- MAY NOTE ARTIFACT LIGHT
- MAY NOTE CONTRACTION CURVE
- MAY CLOSE EYES, ETC.

THERAPIST
- INCREASES PITOCIN (AS REG'D)
- BREAK - PAPERWORK
- MONITOR ON AUDIO
- CHECKS BP
- ENTERS BP ON CHART

- MONITOR TRACING
- NOTES FETAL MOVEMENT
- ENTERS FM ON TRACE
- NOTES MATERNAL MOVEMENT
- ENTERS MM ON TRACE
- NOTES ARTIFACT LIGHT
- ENTERS OCCURRENCES ON TRACE

OCT OPERATION CYCLE
- ENTRY
- BED/LS
- BED/RS
- MON
- IV
- DISPOSE
- SUPPLY
- DESK
PATIENT

CONTINGENCIES, e.g.,
BP DROP, BED LOWERED, ETC.

ELECTRODE MOVEMENT REQUIRED
EQUIPMENT RANGE CHANGES

THERAPIST

CONTINUES MONITOR CYCLE UNTIL THREE
ACCEPTABLE CONTRACTIONS / 10 MIN.

MARKS TEST INTERVAL ON TRACING

TURNS OFF IV PUMP

REMOVES IV

DISPOSES OF NEEDLE

GETS BANDAGE FROM STORAGE

PLACES ON HAND

MARKS TRACING - IV TERMINATED

CONTINUES MONITORING

Fig. 11.
Fig. 12.
Fig. 13.

OCT OPERATION CYCLE

PATIENT —

THERAPIST —

STORES TUBE SUPPORT

DRESSES

DEPARTING INSTRUCTIONS/RESULTS

TEAR OFF TRACE

TRANSMIT TO OR EXAMINE W/MD

PATIENT EXIT
CONSULTATION

LOG/FILE TRACE

FOLLOW UP MAKE READY
PATIENT SUPPORT AND MONITOR

ENTRY
BED/LS
BED/RS
MON
IV
DISPOSE
SUPPLY
DESK
Fig. 15. Flow diagram
women were found, aside from the extreme posture measure of the average female found in the "Body Variations" chart.\textsuperscript{6}

According to Croney, the angle between the upper body support and the lower body support, as shown in figure 18, should be approximately 130 degrees for a body relaxing position. It should be noted that as the back rest seat angle is increased, there must be a corresponding increase in the thigh lower leg angle.\textsuperscript{7}

Dental chairs were reviewed by the designer to compare anthropometric measures. The dimensions taken from two chairs currently on the market and the support dimensions derived from the anthropometric data described earlier are shown in figure 19.

When observing a patient entering and exiting a typical hospital bed, one notices that a sitting position is often first assumed before the patient sits back and lifts the legs to fully enter the bed. In establishing criteria for designing the patient support for the outpatient environment, several factors were considered. First, that it appears to be more difficult for a woman in pregnancy to enter a hospital bed, and exiting seems to be even more difficult. This was confirmed through interviews with several women ranging from six to eight months pregnant. Secondly, during the OCT period (which usually lasts around an hour and a half) it is not unusual for the patient to experience


Anthropometric measures were compiled from AD 743.113.

Clausen, Charles F.

Anthropometry of Air Force Women.

Note: These data do not consider physical changes due to pregnancy.

(Abdominal measures are from Oretuss, H.)

Fig. 16. Anthropometric measures
NOTE: BACK PRESSURE DUE TO LACK OF ADEQUATE LUMBAR SUPPORT & EXTENDED MONITORING TIME IN THE SAME POSITION NECESSARILY PATIENT SHIFTS TO SIDE (MONITORING IS THEREBY AFFECTED) PERHAPS VARIABLE LUMBAR SUPPORT ADJUSTED BY THERAPIST COULD EASE THIS.

ADV. MONITORING SUPPORT USE 2HRS MAX 1.5 AVG. VS. HOSPITAL BED 24 HR/DAY/PATIENT

Fig. 17. Seating criteria
RECLINING: ANTHROPOMETRIC DATA

Semi-supine position for relaxing body: Keegan's angle of 130° between seat and back rest is found to provide maximum muscular relaxation. As the backrest seat angle is increased, there must be a corresponding increase in thigh lower leg angle. For viewing, the angle at knees should be increased (Keeling, J. Anthropometrics for Designers, Van Nostrand Reinhold Co., N.Y. 1971).

Dotted line shows head angle change required for viewing, which would cause neck strain.

Barkla, D.M. "Chair Angles, Duration of Sitting and Comfort Ratings," Ergonomics No. 7 1964

Branton, P. "The Comfort of Easy Chairs" Fibria Report No. 22 1966

Keegan, J.J. "Evaluation and Improvement of Seats," Industrial Medicine & Surgery No. 31 1969

Fig. 18. Seating criteria
Fig. 19. Patient support measures
some lower back discomfort. This is assumed to be due to the increased pressure on the spine (due to pregnancy), and having to remain in the same position during the monitoring procedure. Last, was the fact that the patient in most cases is not considered ill, yet the hospital bed is usually associated with illness.

One factor which allowed more freedom in the design of the patient support was that the length of stay for any one continuous period of time for monitoring is two hours (maximum) per day, as opposed to twenty-four hours (minimum) for a traditional hospital bed. Also, the required positions for a monitoring patient support differ from that of a hospital bed. Figure 17 shows the Semi-Fowlers position normally used for monitoring, in which the upper body is elevated at least 30 degrees. Figure 17 also illustrates the design goals for entering the patient support and specifies a variable lumbar support to relieve back pressure discomfort. In addition, the patient support should be capable of being adjusted to a low, horizontal position to enable the patient to shift to her side, should back pain during monitoring result and the variable lumbar support fail to relieve it. Also, the support should be able to move into a higher horizontal position, making it possible to pull a mobile transport along side the patient support to transfer a patient, should the need arise.

The goal resulting from support design criteria was to design a patient support (deliberately not referred to as a bed to avoid becoming object oriented in the design process) which would not convey the impression of being confining, nor connote illness; which would be capable of assuming a base, or entry position, facilitating entry and exit, and which could be easily manipulated by the therapist to move to other positions.
DESIGN DEVELOPMENT

There is no specific point at which the data gathering phase of the design process terminates and the design phase begins, unless it can be considered to be the point in time at which the designer begins to conceptualize on paper. In practice, however, this is often impossible to define. Data gathering continues far into the design process and, in fact, often includes design follow-up in field testing. Conceptualizing, or ideating usually takes place in the midst of data gathering and observation, as ideas are sketched in the margins of notebooks or on whatever is available to record them.

Initial ideation began by considering the total environment. Numerous sketches were generated and several basic directions evolved from these. Monitor configurations which were remote, wall hung, suspended from overhead tracks, or integrated into a wall were considered, as shown in figures 21-28. As these concepts were being developed, numerous plan layouts were also being considered, a few of which are shown in figure 20.

The flow diagram shown in figure 15 was reviewed and layouts were developed which would minimize the movement required by the therapist during the monitoring procedure. Storage and workspace locations were developed to be adjacent to the point of need.
Figures 26 and 27 show the monitor integrated into the patient support module. This seemed to offer some possibilities; however, the mobility requirements of the monitor, which require that it be used in the labor and delivery rooms, made these approaches impractical. Consideration was given to having the monitoring unit be an integral part of the support module, but be capable of being separated for use elsewhere. This approach was rejected in later studies which showed that the monitor, if rigidly attached to the patient support, tended to obstruct the therapist. A self-standing monitor, as is currently used, is thought to offer more freedom of placement both in the monitoring environment and in other locations.

Various configurations were studied in which the IV supply bottles could be housed. The bottles as well as the IV pump are shown in several locations (see fig. 21-27 & 29). It was a design goal to house the IV supply, such that it would be functionally accessible during setup and monitoring tasks; yet be unobtrusive. The designer felt that the IV pole supports that are currently used are no doubt functional, yet tend to remind one of the paraphernalia associated with intensive care and should not be a part of an outpatient environment. Figures 27 and 29 show the initial concepts to locate the IV supply behind the patient and to be accessible to the therapist. Obviously, this arrangement may not prove to be functional in an intensive care or emergency area where total, unrestricted access is the primary concern. It is, however, felt to be viable in the OCT environment.

The patient support module design, based on the criteria outlined earlier in this paper, evolved from sketch studies, examples of which are shown in figures 30 and 31. Figure 32 illustrates some of the
ideation which went into developing a suitable mechanism to power the support and enable it to adjust to the required positions. Concepts from scissor jacks to linear motors were considered before the final configuration, utilizing a modified four bar mechanism, driven by a unique double thread worm drive was selected. This approach was taken in order to obtain the necessary upward travel, yet maintain a fixed distance between the patient support module and the IV module. This mechanism is shown in figure 52 of the proposal.

The configuration of the fetal monitor was developed through sketch studies, and a full-scale mock-up was constructed to study the relationship of the monitor and the patient support. Through this effort the overall configuration of the monitor, including its height and panel area, were defined. A height was chosen which would allow the monitor to be addressed from a seated position beside the patient (see fig. 43) as well as from a standing position in the delivery or labor areas. It is important that the location of the monitor allow the therapist to operate the monitor and maintain physical contact with the patient in order to properly locate and adjust the maternal leads (transducer and tocodynamometer), to check blood pressure, and to feel for fetal movement. The monitor faces the head of the patient support, enabling the therapist to move from the monitor to the desk, the IV, or to the patient. This location of the monitor also makes it possible for the patient to casually observe the contraction readout on the scope, should she desire to do so. At first it seemed appropriate to situate the monitor so that only the therapist could view the panel. It was felt that this would be placing a barrier between the patient and the therapist and might give the impression that the activities were not to be seen by the patient, that perhaps something irregular might be taking place. In a study on the
psychological responses to fetal monitoring in labor, Starkman notes two roles the monitor seems to fulfill: (1) as a means by which the patient passes time (by watching the output trace or scope), (2) to assist in preparing for contractions and controlling breathing. She observed that some women experienced anxiety because of the continuous auditory feedback of the fetal heart rate from the monitor. Others wanted the feedback even if abnormalities occurred. An earphone jack is provided so that the therapist can eliminate the audio feedback, should the patient find it distracting. It is advisable, however, for the therapist to always monitor the audio to assure that the fetal heart is generating the trace data.

The configuration of the fetal monitor was determined, as previously described, to meet the overall goals of being easily operated from both seated and standing positions to allow good access to the patient by the therapist and to fit into the overall plan with respect to work flow. The monitor components were packaged to achieve the following: (1) provide a horizontal plane in which to locate the trace so that the therapist could easily view the output and comfortably make notes on the trace, (2) provide a control panel which falls within the acceptable viewing angle and range of the therapist, (3) provide an output display at the right of the monitor to be visible by the therapist and the patient, (4) provide access to components from the rear of the unit to allow a technician to make quick checks on the equipment without interfering with the patient, (5) transducer and tocodynamometer leads exiting

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8Monica N. Starkman, "Psychological Responses to the Use of the Fetal Monitor During Labor," Psychosomatic Medicine 38 (July-August 1976): 21
the monitor and connecting conveniently, and not producing trip hazards, (6) ventilation away from the patient and therapist, (7) a balanced configuration to be stable when in use and to allow the unit to be moved around on castors. The fetal monitor proposal is shown in figures 46-49.
Fig. 20. Layout studies
Fig. 21.

Possible ceiling visual treatment to fall within patient's field of vision.
Fig. 27.
Fig. 28.
IV located behind patient's head (out of patient's view but visible to therapist).

Angle of IV support to be such that bottle stability & fluid flow is within acceptable range regardless of position of bed angle. Alternative: Gran Balance Pivot.
Fig. 30.
Fig. 33.

(Biplane cutout used) Parallel to patient support.

As shown, isolates patient from therapist, makes access to patient abdomen difficult.

Has therapist operating device with patient unable to see.
Fig. 35.

- **Interface Module** for invasive monitoring

- **Possible Overflow Storage**
  - Catches try to retain trace of each patient (pouch)
  - Or
  - Roll up storage

- **Full/Flush Control**
  - Counter Pressure Module

- **Electronic Freq**

- Roll up to load trace pak

- **Rec/Transducer connectors**
  - Not interchangable

- **Clinic Repair or Check out during maintainance with empty reservoir away from patient**
Fig. 37.

Mirror & Fiber Optic Projected
Contraction Curve Display
(Patient Viewing)

WARNING & Caution Labels
Located Out of Patient View
Fig. 38.
Fig. 39.
SYSTEM DESCRIPTION

The studies conducted in this thesis resulted in a design proposal for an outpatient environment for ultrasonic fetal monitoring. A one-eighth scale model was constructed to convey design intent (see fig. 40). Presentation sketches were prepared to define the space layout (see fig. 43) and the system components (see figs. 44-54).

The configuration of the system enclosure (see fig. 43), which evolved from layout studies described in the preceding pages, consists of two major wall structures which define the patient and therapist activity space. The arrangement of the patient support, IV module, and the fetal heart monitor establishes the area immediately inside the entry and up to the patient support as the patient activity space. This space gives access to the seating, closet, and patient support. The therapist activity area is considered to be the entire enclosed space; however, the majority of required movements during the monitoring procedure take place between the IV module and the monitor (see fig. 43). The IV is usually administered in the patient's right arm, and blood pressure is taken using the left arm, which is available to the therapist while seated at the monitor.

The wall structures provide support for two storage/worksurface units and house a closet for patient apparel. The unique shape of the enclosure makes the walls self-supporting and provides
additional support for a crossmember, which can be used for movable track lighting and an optional movable tract patient display module. The walls are designed for laminate construction, using a honeycomb core with sheet metal skins.

The plan configuration lends itself to numerous cluster arrangements, should several monitoring areas be desired. Four different cluster arrangements of two modules are possible and many more arrangements are possible with more modules (see fig. 41).

Should open landscape architecture not be available, as in some existing structures, the patient support, IV modules, and the fetal monitor can be placed in an existing room. In this case, where the walls are eliminated, the storage/worksurface units can be fitted with support structures (square steel tube weldments), which make them self-standing.

In order to provide a more pleasing alternative within the patient's field of view (rather than the uninteresting intersection of ceiling and wall) a graphic fabric panel, with a return plane to the ceiling, is located on the wall across from the foot of the patient support. This panel can be fabricated from commercially available wall coverings or could be used for a commissioned tapestry.

The fetal heart monitor shown in figures 47 and 48 is the principal element in the outpatient fetal monitoring environment. The configuration of the proposed design allows the unit to be used either with the therapist seated beside the patient, or standing. The chart writer is horizontally packaged which makes viewing, and writing on the chart more convenient both in the OCT environment and in labor and delivery room use.
A marking system is proposed which would eliminate the tasks of writing fetal movement (FM), maternal movement (MM), IV start, IV terminate, and artifact on the chart; however, blood pressure entries would continue to be written in. The proposed design provides five push buttons, located at the paper entry which, when pressed, would mechanically mark the paper edge with the appropriate code or symbol (see fig. 49).

The hinged deck provides loading access for chart paper. Controls pertaining specifically to the chart are located adjacent to it, these include: zero adjust, calibration (for contraction measures), paper speed buttons (high, low, stop). An artifact light is also located in the horizontal plane adjacent to the chart. This location was chosen because it is not as easily noticed by the patient (the flashing light upsets some), yet it is in the convenient viewing zone for the therapist. The "power off" switch is located on the top surface of the console, where it can be easily identified and accessed in an emergency situation. The following are located in the console readout area: the ultrasound electrocardiograph selection switch and indicators (dead front), the pulse display, an LED resettable timer, and the fetal heart rate display (CRT)(see fig. 49). An earphone jack and audio control are located on the front, lower edge of the worksurface.

Transducer and tocodynamometer cable connecters are located at the rear of the monitor to keep them as much from the patient's view as possible. Incorporated into the cable area is a pull handle to facilitate moving the monitor around. The cables can be draped over the pull handle for temporary storage, or stored inside the rear cover for long term storage.
The rear cover pivots open to allow service access (see fig. 48). Protective inner panels shield the electronic areas from the cable storage area. Test points are readily accessible. Modular packaging of subassemblies makes fault isolation and repair possible with minimum down time. The power cord is located at the lower rear panel and can be plugged into the patient support module base, thereby reducing trip hazards.

The proposed design for a patient support is simple and functional; it does not visually represent a hospital bed, nor does it connote illness or confinement. Its structure is unobtrusive, providing adequate foot room for the therapist and patient. It is adjustable to entry and exit positions (established to make it easy for the pregnant woman to get into and out of). Once the patient is securely seated the therapist can move the support to the Semi-Fowlers position to begin the monitoring procedure. A programmed control is proposed which would allow the therapist to select several positions by pressing a switch. The support logic, which provides input to the positioning drive motors (see fig. 52), could be programmed for other commonly used positions such as those shown in figure 51. Controls for the support module are located along the top edge on both sides. Optional controls could be located on the IV module top surface if this proved feasible. The patient support has two formed cushions (of open cell urethane) with treated fabric covers. These are secured to the structural support by Velcro patches which allow them to be easily removed for cleaning or replacement. The structural support consists of three foam molded shells with flexible molded interconnecting panels to prevent shear points and to provide support across the interfaces. The profile of the side panel makes it possible to use a sheet
and hospital tuck, should this be desired. The pillow is a conventional bed pillow, secured at the top edge with a clip strap to prevent it from slipping down as the support is moved to the entry or exit position.

The IV supply and pump module is located behind the patient (see figs. 50 & 53), to reduce the visual clutter and intensive care associations that some experience on first entering a room with traditional IV support poles. The specific design of the IV pump was not undertaken in this project except to the extent of providing the external packaging sufficient to house the components.

The storage unit located behind the IV supply is for storing supplies associated primarily with the IV. A small sink could be located in this unit, on the end next to the closet, should this be desired. The storage system behind the monitoring station is to serve as a chart analysis and record keeping area. A pinup board is provided to display the fetal heart rate monitoring charts.

The patient display unit concept (see fig. 54) is suggested as an optional feature. Its purpose is to provide the patient with time filling entertainment or instruction, should she desire it. The time required for monitoring and the patient's relative inactivity (contractions excluded) seemed to justify this approach. This unit could range in complexity from a video tape unit (housed in the storage/record keeping desk), and remotely displayed, to a simple cassette film projection unit with or without sound. Instructional tapes could cover such subjects as normal delivery, the first few weeks, breast feeding, etc. Should a CRT display be used, the patient's contraction curve could be displayed, as this is often of interest to the patient. The unit shown in this proposal is
mounted on an overhead track which allows it to be moved away when not in use. In addition, the support column for the display telescopes to allow adjustment (see fig. 54). The anticipated cost of such a device clearly makes it an optional feature.

Lighting is provided by a unit located above the IV storage unit. In addition, an optional spot light unit is located on the overhead support track and can be positioned remotely by draw cords at the end of the track (see fig. 44). It is assumed that additional lighting is provided in the ceiling of the host structure.

Antistatic carpeting (similar to Acrilan 2000+ by Monsanto) is suggested to enhance the environment. The requirement for a smooth surface for improved mobility of crash carts and other equipment used in an intensive care unit does not apply in the outpatient monitoring situation. A plastic, glide surface would be advisable for use beneath the therapist's stool to facilitate her movement in the immediate area.

The colors shown in the color copies in this paper, unfortunately, are not good matches of those chosen for and used in the appearance model. Munsell color notations could, of course, be assigned to assure accurate color matches. The color of the monitor and patient support structure was kept neutral and warm to avoid the cold, sterile appearance often seen in hospital equipment. Large areas of highly saturated color were avoided, as were any colors which absorb too much illumination. Colors that are associated with blood were also avoided. Bright green was selected as an accent color because it seemed to connote life and early spring, which subjectively seemed appropriate for an environment directly concerned with birth and life.
In completing the design of an outpatient environment for fetal monitoring, the designer was left with one question which surfaced in the final stages of the project. The question was, What does this technology offer to those people living in remote areas of this country and in the backward nations of the world? A possible solution to this problem, though it is beyond the scope of this project, would be a mobile fetal heart rate monitoring center containing two or more patient support/monitoring units. This mobile unit could cover outlying areas on a scheduled basis to screen expectant mothers who fall into the high risk category.

Fetal heart rate monitoring is an exciting technology. Hopefully, it will become available to all who may benefit from it.
Fig. 40. Outpatient environment for fetal monitoring
Fig. 41. Arrangements
Fig. 43. Plan view of the outpatient environment
Fig. 45. Model
Fig. 46. The fetal heart rate monitor
Fig. 47. The fetal heart rate monitor
Fig. 48. The fetal heart rate monitor
Fig. 49. The fetal heart rate monitor
Fig. 50. The patient support
Fig. 51. The patient support
Fig. 52. The patient support
IV module

Fig. 53. The IV module
DISPLAY/INSTRUCTIONAL UNIT - OPTIONAL
CAN BE USED TO ENABLE PATIENT TO MORE CONVENIENTLY
MONITOR CONTRACTION GROVE IF DESIRED) OR
INSTRUCTIONAL CASS flash. (FROM REMOTE UNIT IN STORAGE AREA)
DEALING WITH SUBJECTS OF INTEREST TO PATIENT, CAN BE SHOWN
MUSIC OPTION COULD BE AVAILABLE. (HEADPHONES ARE USED TO
PREVENT DISTRACTING THERAPIST WHEN FOR SPINNER IS UNIT.

UNIT TELESCOPES OUT OF USE
(SHOWN IN COLLAPSED POSITION)

Fig. 54. The display unit
the future...
Appendix A
<table>
<thead>
<tr>
<th>Task</th>
<th>Function</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Switch on 'Power'</td>
<td>Depress Switch</td>
<td>Lamps light</td>
</tr>
<tr>
<td>2.</td>
<td>Check Chart Paper</td>
<td>Depress Switch</td>
<td>Red strip if low</td>
</tr>
<tr>
<td>3.</td>
<td>If low, see loading procedure sheets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Insert connector on Statham pressure transducer</td>
<td>'Contraction'</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Depress 'Low' switch</td>
<td>Paper moving 2 cm/min</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Press ↓Hold 'Test' switch</td>
<td>ECG emits 120 BPM</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Holding 'Test' switch depressed,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Press ↓Hold 'Hi/ECG' switch</td>
<td>UDC chart paper speed</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>With 'Test' held depressed slide</td>
<td>120 BPM rate trace</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>'Upper limit adjust' pointer to pos. below 120 heart rate needle</td>
<td>'Alarm reset' indicator flashes</td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>Depress 'Alarm reset'</td>
<td>Slide 'Upper limit adjust' ↑ past 240</td>
<td></td>
</tr>
<tr>
<td></td>
<td>'Lower limit adjust' ↓ below 40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>Check lower limit &amp; repeat step 11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Equipment Setup - Invasive Monitoring**

- Monitor must be connected to approved, grounded 3-lead outlet.
- If patient is connected to other electrical instruments or is in an electrical bed, check that all are at same ground potential.

*Note: Denotes ≤ 10 feet.*

- 120 BPM test
- 2 cm/min
- Flash in synchronism with each beep
- Goes out after 3 ECG beep
- Heart rate at 120
- Pen at 120 on chart
- In place of 120 BPM rate trace
- 16.6 mm/sec

*Track appears on FHR channel.*
Continued:

**STATHAM TRANSDUCER CALIBRATION**

13. **DEPRESS ‘STANDBY’ SWITCH**

14. **ATTACH PRESSURE TRANSDUCER TO SUPPORT RUD**

15. **CONNECT 3 WAY STOPCOCK TO CENTER FITTING ON TOP OF PRESSURE TRANSDUCER**

16. **POSITION HANDLE OFF ARROW POINTING DOWN (TOWARDS TRANSDUCER)**

17. **CONNECT ANGULAR FITTING TO MANOMETER (MER. OR INCHES)**

18. **ATTACH PRESSURE TRANSDUCER CABLE TO ‘CONTRACTION’ OUTLET DAVEL**

19. **DEPRESS ‘LOW’ SWITCH**

20. **WITH MANOMETER AT 0\text{mm} \text{Hg}**

   **ADJUST ‘ZERO ADJUST’ TO ALIGN PEN AT ‘0’ ON CHART LINE**

21. **BEFORE EACH USE OF MONITOR,**

   **CAREFULLY & SLOWLY PUMP MANOMETER TO 100\text{mm} \text{Hg}**

   **& HOLD**

   **ADJUST ‘CALIBRATION’ CONTROL ON MONITOR TO ALIGN PEN TO 100’LINE ON CHART**

22. **RELEASE MANOMETER PRESSURE**

23. **DEPRESS ‘STANDBY’ SWITCH TO DISENGAGE CHART PAPER DRIVE**

**SYSTEM IS NOW READY FOR DIRECT MONITORING**
<table>
<thead>
<tr>
<th>Task</th>
<th>Function</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OPERATIONS - FHR (INDIRECT MONITORING)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Check Transducer (Cloverleaf)</td>
<td>Should be free of residue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. If not clean, clean with soap &amp; water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Rinse under cool running water (Keep water away from connectors)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4. Dry gently with clean cloth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Plug Transducer into 'Ultrasound' Receptacle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Set 'Range' Switch to 12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Apply thin, continuous layer of Gelsonde (or equiv.) to crystals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Set 'Audio Volume' Control to Mid Range</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Place concave surface of Ultrasonic Transducer against</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>exposed maternal abdomen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Rotate 'Range' Switch thru all four positions while</td>
<td>Max Fetal Heart Sound</td>
<td></td>
<td></td>
</tr>
<tr>
<td>listening to fetal heart sounds to maximize</td>
<td>'Pulse' Indicator will flash white in synchronism w/FH Beat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. If no sounds are heard in any position of range switch, return switch to 12 pos.</td>
<td>'Heart Rate' will indicate FHR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Move transducer over abdomen until sounds heard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. If a lot of movement is required, repeat step 7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Repeat step 10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Adjust 'Audio Volume' to desired level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Secure Transducer in place (with tape)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. If tape will not stick to abdomen, clean abdomen w/alcohol</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. If FH sounds weaken, fetus may have moved, repeat 12-14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. In monitoring - while wide trace and 'artifact' lit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. If alarm monitoring, FHR is desired set limits w/pointers</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Gelsonde - Ultrasonic Coupling Medium**
- Slow drying, non-conductive (6)
- Water soluble
- Note: Position on midline, halfway between pubis and umbilicus.

**Use Headset if privacy is required**
- Leave ample slack to permit maternal movement
d. Tincture of Benzoin (Remove Gel with dry cloth)
- Heart signal validity in doubt
<table>
<thead>
<tr>
<th>Task</th>
<th>Function</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPERATIONS - UTERINE CONTRACTIONS - (INDIRECT MONITORING)</td>
<td>UC - NON-INVASIVE MONITORING</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. CHECK THAT CONCAVE SURFACE OF TOCOTRONOMETER IS FREE OF RESIDUE
2. IF NOT CLEAN, CLEAN WITH SOAP \( \frac{1}{2} \) WATER, DRY W/CLOTH
3. ATTACH TOCOTRONOMETER CABLE CONNECTOR TO 'CONTRACTION' RECEPTACLE
4. PLACE CONCAVE SURFACE OF TOCO AGAINST EXPOSED MATERNAL ABDOMEN POSITION OVER FUNDUS ON ABDOMINAL MIDDLE OR AREA OF GREATEST MOTION DURING CONTRACTION
5. CHECK THAT THERE IS AMple CABLE SLACK \( \frac{1}{2} \)
6. SECURE TOCOTRONOMETER WITH SURGICAL ADHESIVE TAPE
7. DEPRESS 'LOW' SWITCH TO START PAPER \( 2 \text{cm/min} \) \( \text{UC RECORDEO} \)

| NOTE: WITH TOCOTRONOMETER TAPE IN PLACE | |

- THERE WILL BE A SLIGHT POSITIVE SHIFT IN THE UC PRESSURE BASELINE...
- THIS DENOTES UTERINE TONUS
- DO NOT ADJUST OUT -
**OPERATIONS - FETAL HEART RATE (DIRECT MONITORING)**

DIRECT MEASUREMENT OF THE FHR IS DERIVED FROM THE FETAL ELECTROCARDIOGRAM (FECG) WHICH IS DETECTED BY CLIP ELECTRODE, ATTACHED TO PRESENTING PART. THE CLIP HAS A LOODED COIL WHICH MAKES ELECTRICAL CONTACT WITH THE FETUS THROUGH THE VAGINAL FLUIDS. THE DETECTED FECG IS ELECTRONICALLY PROCESSED AND COUNTED BY A BEAT-TO-BEAT CARDIOTACHOMETER, WHICH COMPUTES THE FETAL HEART RATE.

---

**WITH IUC ALREADY IN PLACE**

1. Plug leg plate into ECG receptacle
2. Prepare sterile items. Items should be in a sterile field.
3. Check operation of light (assistant)
4. Tape leg plate to medial aspect of thigh (assistant) | terminals clear
5. Prepare 2 inch skin area on medial aspect of isolateral thigh (assistant) (rub skin vigorously with alcohol swap, allow to dry)
6. Apply electrode paste to exposed center area of maternal electrode
7. Peel off protective strip, apply to prepared skin, press perimeter of electrode firmly
8. Push maternal electrode plug into center terminal of ECG plate
9. Attach leg plate connector to ECG receptacle on monitor
10. Insert endoscope & fetal ECG electrode:
    a. Don gloves, sterile if not already on
    b. Assistant places light into sterile endoscope held by operator.
    c. Insert fetal ECG electrode into forceps, return forceps to sterile field.
    d. Turn on light, aim toward appropriate fornix (via forceps)

---

**NOTE:** If electrode is shifted, use new electrode.
10. Carefully insert small end of endoscope into vagina until cervix is encountered.

E. Slowly bring small end over rim of cervix.

q. Insert forceps (w/ cotton swab attached) into endoscope 4. Sponge pres. part of fetus

h. Withdraw forceps 4 swab

i. While viewing PP of fetus, introduce forceps (w/fecg electrode attached) through endoscope.

j. When fecg electrode points contact PP of fetus, apply gentle pressure against the PP. part.

k. Close forceps to attach electrode

l. Hold forceps closed for several seconds to be sure electrode is firmly attached.

m. Remove forceps

n. Apply light traction to fecg electrode to assure firm attachment to fetus (if electrode loose, use new one)

o. Push fecg electrode plugs into outer terminals of leg plate (interchangeable)

p. Adjust audio volume as desired

11. Depress 4 hold 'hi/ecg' switch

r. Check qrs complexes of fetal ecg waveform to see if visible on chart.

s. Release 'hi/ecg' switch

t. Unplug fetal ecg leads from leg plate, re plug

u. Remove endoscope

v. Reattach ecg leads to leg plate 4 tape plugs in situ

w. Recheck electrode

11. To record fhr press 'low' switch

FHR INVASIVE MONITORING (CONT.)

NOTE: Recommended that endoscope be held in place steps q. through n

NOTE IF BEAT TO BEAT INTERVAL SPACING OF FH SIG.

SHOULD CHANGE AT RATE > 120 BPM

'ARTIFACT' INDICATOR WILL LIGHT 4 WIDE TRACER WILL APPEAR ON CHART FHR CINDICATOR WILL REMAIN LIT UNTIL 3 CONSECUTIVE FETAL HEART BEATS W/BP < 120

WHEN LIT: DISRECKD HEART RATE 4 TRACE

NOTE: HEART RATE LIMITS SHOULD BE SET AS DESIRED TO ACTIVATE ALARM.
### OPERATIONS - INTRAUTERINE PRESSURE (DIRECT MONITORING)

1. **Attach pressure transducer mount/clamp to suitable support**
2. **Place PT in clamp & adjust height to level of fundus**
3. **Tighten clamp**
4. **If calibrated prior to use proceed - If not Calibrate**
5. **Interconnect PT, filled syringe & two 3-way stopcocks**
6. **Position stopcock handles as shown - FIG A**
7. **Slowly depress syringe to completely fill PT dome with sterile distilled water - No air bubbles should be seen in plastic dome!**
8. **Connect an additional 3-way stopcock in series with angular fitting on PT**
9. **Move syringe to fitting on added stopcock & reposition handles as shown - FIG B**
10. **Prepare patient for catheter insertion**
    a. In bed - elevate pelvis (place on bedpan etc.)
    b. Don sterile gloves, prep perineum w/0.2% germicide
    c. Drape bedpan, legs & suprapubic area w/ poly. towels
    d. Determine location of presenting part
    e. Perform amniotomy if amnion is still intact
11. **Prepare sterile items**
    a. Unpack remaining sterile items, place in sterile field
    b. Check 16-gauge blunt needle is firmly seated in unperforated end of catheter
    c. Fill syringe with 10 cc of sterile distilled water

---

**UC INVASIVE MONITORING**

[Diagram of setup for filling and final setup (after filling)]
12. INSERT INTRAUTERINE CATHETER:
   a. PLACE EXAMINING FINGERS BETWEEN CERVIX AND PRESENTING PART
   b. CAREFULLY PASS CATHETER GUIDE BETWEEN FINGERS AND
      INTO UTERUS UNTIL INSERTED END IS NEXT TO PRESENTING PART
   c. THREAD PERFORATED END OF CATHETER THROUGH GUIDE
      UNTIL BLACK MARK ON CATH. REACHES GUIDE END
   d. WITHDRAW CATHETER GUIDE FROM VAGINA AND
      SLIDE IT BACK ON CATH. SO THAT IT IS NOT IN THE WAY.
      CHECK THAT AMNIOTIC FLUID FLOWS.
   e. CONNECT FREE END OF CATHETER TO STOPCOCK FITTING. FIG. C
   f. DEPRESS SYRINGE TO FLUSH AND FILL CATHETER
      MAKE SURE NO AIR BUBBLES ARE VISIBLE IN CATHETER TUBING.
   g. REMOVE GLOVES
   h. POSITION PT ON SUPPORT ROD AT PATIENTS 2 VAGINA LEVEL
   i. PRESS 'LOW' SWITCH TO START PAPER
   j. USE 'ZERO ADJUST' TO ALIGN PEN IN UC CHANNEL WITH 'O' LINE
   k. POSITION STOPCOCK HANDLES AS SHOWN FIG. D
   l. BEGIN RECORDING INTRAUTERINE PRESSURE (BASELINE SHIFT
      DENOTES TONE)

M. TAPE CATHETER TO PATIENTS THIGH TO MINIMIZE POSSIBILITY
   OF ACCIDENTAL REMOVAL

NOTE: IF AT ANY TIME IT IS DESIRED TO REFRESH THE CATHETER W/ REZERO
   UC CHANNEL, SEE FIG. C & E WHEN COMPLETED RETURN TO
   POSITION SHOWN FIG. D

NOTE: TO FUNCTIONALLY CHECK SYSTEM, APPLY FUNDA PLAN PRESSURE
   A CONCOMITANT INCREASE IN UTER. P. SHOULD BE OBSERVED IN CHART

<table>
<thead>
<tr>
<th>UC INVASIVE MONITORING (CON)</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Task</strong></td>
<td><strong>Function</strong></td>
</tr>
<tr>
<td>I.</td>
<td><strong>Input</strong></td>
</tr>
<tr>
<td>J.</td>
<td><strong>Output</strong></td>
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<tr>
<td>k.</td>
<td><strong>UC INVASIVE MONITORING (CON)</strong></td>
</tr>
<tr>
<td>l.</td>
<td>(TO ASSIST GUIDE)</td>
</tr>
</tbody>
</table>

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![Diagram](image-url)
SELECTED BIBLIOGRAPHY


O'Gureck, Joan E. "A Practical Classification of Fetal Heart Rate Patterns." Obstetrics and Gynecology 40 (September 1972): 356-60.


