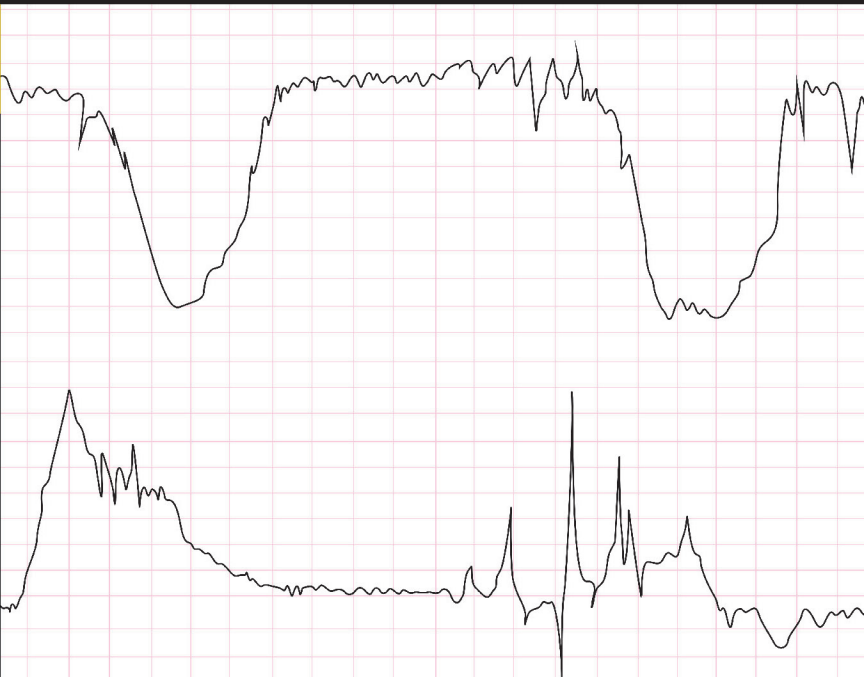
ur website www.jaypeebrothers.com, for detailed information on obstetrics & gynecology books, visit our website www.jaypeebrothers.com





Practical Cardiotocography

AK Debdas

4th Edition

JAYPEE

Contents

1. What is Cardiotocography? 1
2. Pioneers of Cardiotocography 3
3. Scope of Use of Cardiotocography 5
4. The Need for Cardiotocographic Monitoring 10

5A. Methods Used for Picking-up Fetal Heart Activity 15

5B. A New Species of Cardiotocography Machine 42

6. Methods of Picking-up Uterine Activity: Tocography 45
7. General Description of CTG Machine and its Various Switches, Control, and Displays 54
8. How to Choose a Machine? 70
9. Electrical Requirement and Environment 76
10. Machine Testing by the User 79
11. Machine Servicing 81
12. Cardiotocography Interpretation: Theoretical Considerations 83
13. CTG Interpretation—Examples of Tracings and Analysis—"CTG Made Easy" 131
14. Problems in Interpretation of Cardiotocography and Solution 193
15. Applied Cardiotocography: Antenatal 197
16. Uterine Activity: Normal and Abnormal 214
17. Applied Cardiotocography: Intranatal 225
18. Fetal Sleep, Rest, Activity, and Cardiotocography 242

19. Fetal Vibroacoustic Stimulation Test by Cardiotocography 248
20. Computer Analysis and Use of Artificial Intelligence: AI on Cardiotocography Trace 262
21. Cardiotocography cum Fetal Electrocardiogram: An Approach Toward Precision 271
22. Nonreassuring Cardiotocography Trace 278
23. Beyond Cardiotocography 286
24. Role of Cardiotocography for Patients Getting Epidural Analgesia in Labor 291
25. Effects of Narcotic Drugs on Cardiotocography 295
26. Special Problems of Cardiotocography Monitoring of Preterm Pregnancy 298
27. Monitoring Twins by Cardiotocography 302
28. Cardiotocography through Telemetry 306
29. Clinical Considerations in Interpretation of Abnormal Trace and its Management 308
30. Medicolegal Considerations of Cardiotocography 316
31. Drawbacks and Deficiencies of Cardiotocography Monitoring 321
32. Place of Cardiotocography Today 326
33. Special Features of Cardiotocography of Second Stage of Labor 338
34. NICE Guidelines for Cardiotocography Interpretation 341
35. Cardiotocography, Biophysical Profile, and Doppler: Comparative Scope and Interrelation 344

36. Cardiotocography and Fetal Acidosis 347

37. Cardiotocography and Cerebral Palsy.....349

38. Assumptions and Presumptions about Cardiotocography Monitoring 351

39. Training and Education for Cardiotocography Interpretation 353

40. Cardiotocography: Complications and Contraindications.....355

Recommended Further Reading.....357

Index.....359

CHAPTER

7 General Description of CTG Machine and its Various Switches, Control, and Displays

INTRODUCTION

Though the body of the machine, specially those which provide both internal and external monitoring facilities, may appear a bit complicated at first sight, on critical look specially from functional angle, it will turn out as a very simple machine. Here is a list of the various features of a standard cardiotocography (CTG) machine under broad headings:

- Machine on/off switch
- Features concerned with fetal heart (FH) monitoring
- Features concerned with uterine contraction monitoring
- Switches for the recorder (paper drive)
- Switches for annotation (for writing and marking)
- LCD display facility
- Memory
- Home/Distance monitoring
- Features of the CTG tracing paper
- Arrangements for alarm
- Portability of CTG machine

Figure 7.1 shows the general CTG machine in which some generalization has been made for easy understanding and for building a clear concept about any CTG machine of any make (except that of the new

JAYPEE BROTHERS

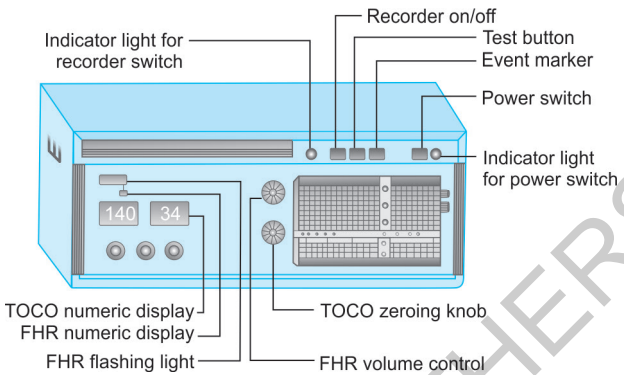


Fig. 7.1: General cardiotocography (CTG) machine depicts some generalization of switches, controls and displays of CTG machines. (FHR: fetal heart rate)

species CTG machine—please *see* Chapter 5B and Plate 1 at the beginning of the book).

MACHINE ON/OFF SWITCH

This is actually power on/off switch. Some machines provide an indicator light which comes "on" when this switch is turned on. If the machine appears totally inoperative, examine this switch and also the main source of power—the simple fault (no power) may be the cause.

FEATURES CONCERNED WITH FETAL HEART MONITORING

Features concerning FH monitoring depending on the make and model of the machine as follows:

- *Socket for ultrasonic FH transducer plug:* The socket and the plug usually have the same color to facilitate identification and avoid confusion so that the TOCO transducer (of different color) is not plugged in FH

JAYPEE BROTHERS

socket by mistake and vice versa. In some machines as the transducer is plugged in the socket an indicator light comes on to show that the plugging has been proper.

- *Digital display of fetal heart rate (FHR):* This is a very prominent and important feature of the machine located on its front panel. By simply, glancing at this window one can judge from a distance the basic behavior of FH, e.g., tachycardia, bradycardia, etc.
- *Flashing light display of FHR:* In addition to the digital display most machines also have a small light on the front panel which flashes in the rhythm of FH.
- *FHR signal "quality" display window:* Some machines incorporate this very useful facility in the design of traffic light signal—a window each for green, yellow, and red light signifying optimal signal, fair signal, and unacceptable signal, respectively. This arrangement helps in:
  - Proper positioning of the ultrasound (US) transducer, i.e., right over FH—where external abdominal approach has been used for FH monitoring.
  - It also serves to indicate the right placement of scalp electrode, i.e., whether it is anchored properly—where the internal electrocardiogram (ECG) mode has been used to pick-up FH activity.
- *Fetal heart sound (FHS) audio volume control knob:* This is useful in demonstrating FHS to the mother. A busy nurse in labor room can keep tabs on FH by raising its volume while doing other jobs.
- *FHR abnormality "alarm" bell/light:* Not all machines provide this. The alarm comes on when the normal range of FHR is exceeded. Obviously, for using this facility the desired upper and lower limits of FHR has to be preset (*see* later).

JAYPEE BROTHERS

- *Socket for "direct" fetal ECG:* This is meant for the plug coming from the scalp electrode.
- *FHR tracing on/off switch:* This is same as "recorder switch" (*see* below) and is meant to drive (roll out) or stop the tracing paper. It also activates the pen which draws the tracing.

FEATURES CONCERNED WITH UTERINE CONTRACTION MONITORING

- *Socket for TOCO transducer:* Like the socket and plug for the ultrasonic FH transducer (*see* above) in this case also the socket and the transducer plug is color-matched to avoid confusion with the FH transducer plug. Some machines have indicator light to show the mode that is being used to pick up uterine contraction (whether external or internal mode) which comes on as the socket is plugged in with the appropriate type of transducer. The TOCO socket is usually common for both internal (intra-amniotic catheter mode) and external (abdominal TOCO transducer mode) tocography.
- *TOCO baseline setter knob or zeroing knob:* This cancels the atmospheric pressure to zero so as to eliminate it from the measured intrauterine pressure. For external tocography, it fixes the baseline to a preset level (*see* "External Tocography" in Chapter 6: Methods of Picking-up Uterine Activity: Tocography).
- *TOCO amplitude (i.e., intra-amniotic pressure level) numeric display:* This shows the intrauterine pressure level in kPa or mm Hg. Being an invasive method, the internal TOCO is mostly not used. This has been substituted by electromyography which is an external method (*see* Chapter 6).

JAYPEE BROTHERS

- *TOCO tracing on/off switch:* This is same as "recorder switch" (*see* below) and is common with FH tracing on/off switch.

SWITCHES FOR THE RECORDER

The recorder is concerned with paper drive and pen drive so that the pens trace the events picked up by the machine on the paper in ongoing manner. There are four switches concerned with the recorder mentioned as follows:

1. *Tracing on/off switch:* On pressing this switch both FHR and TOCO pens start writing on the CTG tracing paper, simultaneously, and the paper also starts rolling out.
2. *Switch for the manual advancement of paper:* This is required as one shifts the machine from one case to the next so as to be able to tear off the tracing of the last patient with a clear margin.
3. *Switch for adjustment of tracing paper speed:* Most machines give choice of three speeds: 1, 2, and 3 cm/min. This switch is usually located on one of the side panels or on the backside of the recorder assembly.
4. *Loading and unloading of tracing paper:* It is quite simple but varies in details from one make of the machine to another. The manual book of each machine gives its own particular way.

PRINTER FACILITY

Some of the newer CTG machines have, as a part of it, a detachable printer like the "computer–printer". The CTG tracing on paper in these machines is given out by this part of the system instead of the conventional inbuilt

JAYPEE BROTHERS

recorder as in a conventional CTG machine. Some of the sophisticated printers have even the *analysis–logic software* incorporated in it. So, these not only print the tracing but also the result of the analysis of the issuing graph.

SWITCHES FOR ANNOTATION

These means switches for writing and marking on the CTG tracing paper, i.e., for making note:

- *Automatic annotation facility:* Almost all machines with dual monitoring facility print the following data automatically—date, time, mode of picking up FH activity, (whether internal or external), mode of picking up uterine contraction (whether internal or external), and paper speed. This it does (usually) at 10 minutes' interval on the narrow blank space at the junction of the FH portion and the TOCO portion of the tracing paper (*see* sample tracings in Chapter 13). These data are of great importance in analyzing and following up of a case.
- *Clinical event maker button:* On pressing this button an arrow or some other sign (varies with the machine) gets printed on the tracing paper to mark some clinical event, for example, the point of time when acoustic stimulation was given, membranes were ruptured, meconium first appeared, etc. This button is, usually located right on the body of the machine.
- *Remote event maker:* This is a switch at the end of a long flex which is plugged into the appropriate socket on the CTG machine. This switch is given to the mother when she is having her CTG done. She is instructed to press the switch as and when she feels fetal movement (FM) and as soon as she presses the

JAYPEE BROTHERS

switch, depending on the make of the machine either an arrow or a thin pointed line or the letters FM or some other sign gets printed on the chart denoting occurrence of FM at that point. It is from these markings that the FM frequency and the occurrence of FM acceleration is assessed. This remote switch is also called by some "patients" button.

- *Acoustic stimulation marker:* Machines which have a socket for plugging in acoustic stimulator print a sign of musical note on the tracing paper the moment the stimulator switch is pressed (*see* the Chapter 19 on VAST).

LCD DISPLAY FACILITY

Nowadays, all machines have a screen in the front panel which display all monitoring parameters in real time including the graphs. This has the major advantage of doing continuous monitoring but without paper, i.e., it saves expensive paper. If obstetrician desires to permanently record any segment of the tracing on display it can be done by simply pressing the recorder switch. Undoubtedly, this is a very useful facility.

MEMORY

Newer machines have storage capacity (memory) of holding 6 hours' data—both alphanumeric and graphic. So, CTG monitoring done on a patient some hours or days back but without paper tracing can be called back and if necessary, be printed at any time. Through this facility, data of many patients can be stored in one machine.

This facility is of particular advantage for home monitoring. CTG of several patients can be taken by a junior doctor or an obstetric nurse at patients home

JAYPEE BROTHERS

and then when the machine is brought back to hospital the tracings taken earlier at home can be accessed for analysis by a senior doctor who can also match the CTG findings with patients clinical data which is available at the hospital.

HOME/DISTANCE MONITORING

See Chapter 28 on Telemetry.

FEATURES OF CTG TRACING PAPER

A clear knowledge about the format of the CTG tracing paper is important for prompt and correct interpretation of the tracings that come on it. But, unfortunately, this most simple and basic component of CTG procedure has not yet been standardized—each manufacturer using a slightly different format. Here is a summary of the basic features of CTG tracing paper.

Paper Width

For most makes of the machine, the paper width is more or less around 150 mm, but the chart papers are not interchangeable between one make of the machine to another.

Recording Channels

Basically, all machines have two channels which are mentioned as follows:

1. *Top channel (80 mm)*: This is for FHR recording.
2. *Bottom channel (40 mm)*: This is for uterine contraction recording (TOCO channel)

Machines with dual FHR monitoring facility for twins depicts and prints the FHR traces of two fetuses:

JAYPEE BROTHERS

(1) either one above the other in which case the FHR channel is divided into an upper and lower half of 40 mm each with one half for each fetus, or (2) prints them together across the full 80 mm width of the FHR channel like this—of that of one fetus *in dark* and that of the other *in light ink*.

About the facility for automatic printing (every 10 minutes) of date, time, monitoring mode, and paper speed—the details have already been mentioned above. These are printed in the blank space between the FHR and the TOCO channel.

Machines with actocardiograph facility print occurrence of FM either in "dot print" or as "tiny black squares" near the upper border of either FHR channel or TOCO channel or "as grassy marks (spikes)" near the bottom of the TOCO channel (*see* **Fig. 13.49**).

FHR Range—As Printed on the Chart Paper

Papers of some monitors print 50–210 or beats/min or 30–240 beats/min.

STEPS OF FHR INCREMENT AND DECREMENT DEPICTION

As denoted by the distance between the horizontal lines on the chart paper **(Table 7.1)**.

See **Figure 7.2** and the actual tracings in the Chapter 13.

This is a very important feature and can cause a lot of confusion in interpretation of the tracings because interpretation is generally done by "visual impression" of the size of the humps and depressions of the FHR tracing line. The confusion occurs under the following situations.

JAYPEE BROTHERS

TABLE 7.1: Steps of fetal heart rate (FHR), no. of horizontal lines in between and beats/min intervals shown in comparative manner.

Names of Company	*Steps of FHR as printed on chart*	*No. of horizontal lines in between two printed FHR figures*	*Beats/min interval between two consecutive horizontal lines*
Hewlett–Packard (HP)	Step of 20 beats/min, e.g., 100, 120, 140, etc.	4 lines	5 beats/min
Corometrics	Step of 30 beats/min, e.g., 90, 120, 150, etc.	3 lines	10 lines
Toitu	Step of 20 beats/min, e.g., 100, 120, 140, etc.	10 beats/min	2 beats/min

JAYPEE BROTHERS

- When one unit has two machines of two different companies using papers of two different specifications
- When the same patient is monitored by a machine of one make 1 day and another make another day—each using their own brand of tracing paper
- When an obstetrician, who is used to chart paper of one make of CTG machine, happens to judge or compare the tracing coming out of machine of another make using another kind of paper

Given above is a comparison of chart paper (FHR channel only) of three different manufacturers (also *see* **Fig. 7.2**).

Figure 7.2 shows a slice each of the three types of charts.

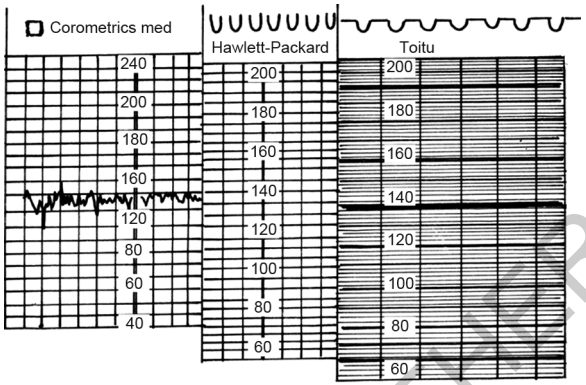


Fig. 7.2: A slice of fetal heart rate (FHR) chart of three different makes. Note how different they are.

Note: Features vary from model to model of the same company.

It is quite apparent from the above-mentioned table that how confusing it is to compare three charts of three different machines, specially visually, and hence, there is an urgent need for standardization of the chart paper internationally.

PAPER FEATURES OF TOCO TRACING

Here also there is some nonuniformity as shown in **Figure 7.3**. Whereas, the amplitude of contraction is depicted in either mm Hg or kPa or in both in papers of some make and some others do not print the unit of measurement at all.

Though unrelated to actual tocography, some manufactures use the TOCO section of the paper to provide columns for entering the observations, e.g., dilatation of cervix, effacement, station, state of membranes, mother's pulse, temperature, blood

JAYPEE BROTHERS

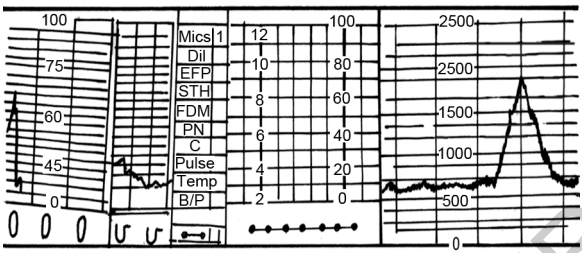


Fig. 7.3: A slice of TOCO chart of four kinds which seem to be so different.

pressure (BP), medication given, pH of fetal blood, oxymetry findings, etc., for labor cases.

Paper Speed

Unfortunately, between manufactures, there is no uniformity in this feature either. While some companies give a choice of three speeds, i.e., 1, 2, and 3 cm/min, some other companies offer only two choices—1 and 3 cm/min. One can well imagine how different the same FHR tracing would look, if run first on 1 cm/min and then on 3 cm/min speed, and the consequent diagnostic problem.

RECOMMENDATION

Working party on "cardiotocography technology" organized by the Royal College of Obstetricians and Gynecologists of London recommends the following for FHR display in CTG: a range of 50–210 beats/min at 20 beats/min/cm scale sensitivity and a paper speed of 1 cm/min, so that the visual appearance of the

JAYPEE BROTHERS

recording would be the same irrespective of the make of the machine used (Carter and Steer, 1993).

ARRANGEMENT FOR ALARM

For Fetal Heart Rate

- In some machines one can set *rate base alarm* for a chosen lower and higher limit of FHR, e.g., at 110 and 160 beats/min.
- In some machines there is arrangement for *signal loss base alarm* so that if there occurs FH signal loss exceeding 30% in any 10-minute period, alarm goes so that one attends the case to set the problem right. Two common causes of signal loss are change in fetal position and hence, that of its heart and transducer or scalp electrode displacement.

For TOCO

Some machines have arrangement so that alarm goes *if no contraction is recorded for a continuous period of 10 minutes* so that due attention may be given to the case.

The possible causes of nonrecording of contractions and their solutions are:

- TOCO disc displacement—needs repositioning
- Intrauterine pressure catheter displacement—needs repositioning
- Truly infrequent contraction (slow labor), i.e., stimulation of contraction by oxytocic may be considered
- A possible case of "false pain" consider necessary treatment.

JAYPEE BROTHERS

- A possible case of premature labor institute appropriate treatment.

PORTABILITY OF CARDIOTOCOGRAPHY MACHINE

Nowadays, all CTG machines are small and lightweight and hence can be carried by hand. However, one may like to use a small trolley. Size has been reduced to roughly 10–12″ in all dimensions—width, height, and depth, and the weight also reduced to <2 kg. Some manufacturers have even separated the printer which now may or may not be carried to the patient. In these models, one can see the tracing on LCD screen, store the whole recording in the memory, and later have it printed if required.

Advantages of Portability

The very small machines which can be carried in hand have the following advantages:

- By one machine one can cover many locations such as antenatal clinic, antenatal ward, and labor room.
- For patients who should not be moved such as antepartum hemorrhage (APH) patients, hypertension patients under heavy sedation, and cases of threatened premature labor, the machine can be taken to patient's bedside. Similarly, for emergency cases, it can be taken to emergency room.
- For intrauterine growth restriction (IUGR) patients who cannot afford admission to hospital or nursing home and who must rest, the machine can be carried to patient's home. In fact, this way hospital

JAYPEE BROTHERS

admission and thereby overcrowding of hospital can be reduced.

- As the machine hardly takes any space, it is ideal for private chamber (office) of the obstetrician where the space available is usually limited.
  Note: Carrying the machine in hand is usually better than wheeling it on a trolley with ill-fitted wheels and specially where stairs have to be negotiated.

However, the advent of beltless transducer, wireless transmission of signals, and use of Bluetooth and mobile technology has greatly decreased the necessity of carrying around of the CTG machine.

FURTHER READING

1. Analogic FetalGard Lite CTG machine-NIBP. United States: Analogic Corporation; 2003.
2. Antepartum Monitor-FM-2, M-1351A, Intrapartum Fetal Monitor-Series 50 IP-2, 2010. Netherland: Philips Fetal Monitors.
3. Baby Dopplex 4000. Cardiff: Huntleigh Fetal Monitors; 2007.
4. BPL Fetal Monitor—9533, Fetal cum Maternal Monitor-FM 9714. Bengaluru, India: BPL Healthcare.
5. Carter MC, Steer PJ. Brit J Obstet Gynaecol. 1993; 100(Suppl 9):1-36.
6. Corometrics Fetal monitor—Model 145 Operator's manual: Corometrics Medical systems, INC. 1992;1-27. Now represented by GE USA, 2005.
7. Hewlett Packard Gmbh D-7030, Boblingen: Operating guide for fetal monitor Model 8040A and Technical information leaflets 1984 and 1986. Printed in the Federal Republic of Germany, 1983;84:86. Now represented by Philips, Netherland, 2002.

JAYPEE BROTHERS

8. Janitri Innovations. Keyar CM CTG machine. Instructional Manual. [online] Available from www.janitri.in [Last accessed November, 2023].
9. Sonicaid TEAM Fetal monitor—User's guide: Publication No. 8909–8500, Issue 2,1. Kimber Road, United Kingdom: Oxford University Press; 1996; 45-73; 99-111; 143-144.
10. Steer PJ. Fetal heart rate patterns and their clinical interpretations. Sussex: Oxford Sonicaid Ltd.; 1986. pp. 1-45.
11. Toitu CTG Machine brochure and Toitu guide to fetal heart rate monitoring, Toitu Co. Ltd., 1-5-10, Ebisu-Nishi, Shibuya-Ku, Tokyo, 150 Japan.

JAYPEE BROTHERS

for detailed information on obstetrics & gynecology books, visit our website www.jaypeebrothers.com, for detailed information on obstetrics &

Practical Cardiotocography

Salient Features

- Cardiotocography (CTG) seems to have stood the test of time—64 long years of active clinical use and still an ever-increasing number of users and manufacturers
- The need for CTG is varied and so many—physiological, technical, clinical, social, medicolegal, professional, etc
- The struck objectivity and simplicity of vibroacoustic stimulation test (VAST) by CTG is to be seen to believe. Even a nurse can interpret it
- CTG begins where biophysical profile (BPP) and Doppler end
- CTG is needed before and after fetal blood sampling (FBS) and pulse oximetry tests
- CTG is a must for scientific fetal care
- As regards the problem of interpretation of CTG traces, through 50 case studies, this book has made CTG interpretation infinitely easy even for a junior doctor.



AK Debdas MD (Kol) FRCOG (London) FRCS (Edin) FICOG is an author of seven books. He has been an Honorary Associate Professor of MGM Medical College, Jamshedpur, Jharkhand, India. He is a visiting Lecturer of National Academy of Medical Sciences, New Delhi, India. He is an examiner of eight universities and national board including PhD examination. He runs a research unit, having several original scientific contributions, such as Growth Tape, Multifetal Monitoring Circuit with Telemetry, Autocraniotomy Apparatus, Obstetric Chronochart, Descentmeter, Hands-free Fetal Monitoring Device, and VAST Stimulator. He is a recipient of six FOGSI (Federation of Obstetric and Gynaecological Societies of India) awards, including the "Corion Research Award".

Printed in India

Available at all medical bookstores or buy online at www.jaypeebrothers.com

JAYPEE BROTHERS
Medical Publishers (P) Ltd.
EMCA House, 23/23-B, Ansari Road, Daryaganj, New Delhi - 110 002, INDIA
www.jaypeebrothers.com

Join us on facebook.com/JaypeeMedicalPublishers

Shelving Recommendation
OBSTETRICS & GYNECOLOGY

ISBN 978-93-5696-443-3