

ESSENTIAL NONINVASIVE MONITORING IN ANESTHESIA

Edited by

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INTRODUCTION

J.S. Gravenstein

The terms "monitoring," "essential" and "noninvasive" in the book title require clarification.

Monitoring is a term now widely used in medicine. I find it linguistically astonishing that the noun "monitor" refers to a machine, usually an electronic device, yet the verb "to monitor" is an activity carried out by either man or machine.

"We monitor this patient," we say; or "The patient is on an ECG monitor." We might also say, "We are monitoring the patient's ECG," but we never refer to ourselves as monitors. The monitor is the ECG oscilloscope.

Compare the "observer" who "observes" the patient and the "guard" who "guards" the gates. Here noun and verb keep their relationship intact. The man who observes is the observer, the guard is the fellow who guards, the driver does the driving and the monitor the monitoring, except that I can monitor a patient without turning into a monitor myself. Though no one would accuse me of using improper English were I to call myself a monitor, it simply is not done.

There is some wisdom in the way usage has formed these patterns. Monitoring is a repetitive, fatiguing job that machines do extremely well and people do poorly. The same signals have to be sampled over and over again, often more frequently than is possible for a person. In the course of a surgical operation, an anesthesiologist can take and record blood pressure by hand no more than every five minutes -- and at times not for 20 minutes -- until other responsibilities of high priority have been satisfied. Dangerous changes in blood pressure can of course develop in much less than five minutes. Here an automated monitor serves well.

Thus the usage recognizes the delegation of an activity (to monitor) to a machine (the monitor). The machine monitor must give a signal when dangerous deviations occur because people are unsteady observers of machine signals collected so accurately, quickly, frequently and monotonously. We might monitor with the help of the machine, but we delegate the collection of signals and sounding of alarms to dumb machines. That is the sense in which monitoring is used in this book.

Essential monitoring refers to the monitoring we believe necessary for safe anesthesia practice. We can think of no circumstance in which an anesthetic would be given with the anesthetist unaware of the patient's blood pressure and ECG. We also require an accessible facility for gas determinations. These constitute minimal and essential monitoring by our definition. Of course, many more monitors may be added in special circumstances. They may become essential for certain categories of patients. However the additional monitors may be applied, the essential ones are still the backbone of the monitoring effort.

We admit that we have no solid data to show that anesthesia would have a bad outcome were we to omit blood pressure, ECG and gas monitoring. Nevertheless, clinical experience, general usage in the United States and sparse data compel us to call blood pressure, ECG and gas monitoring essential at this time. In the future new and more reliable information may become available, and our tentative 1979-80 definition of essential monitoring will change.

Noninvasiveness for routine monitoring is necessary. Invasiveness requires meticulous placement of sensors which in turn depends upon manual skills, costly equipment and sterile procedures. These time-consuming manipulations cannot be tolerated in everyday routine procedures. In addition, the palpable discomfort of the patient and potential complications limit invasive procedures to the few situations where the benefits are persuasive. For routine monitoring only noninvasive methods are acceptable. Indeed "essential," "routine" and "noninvasive" overlap as concepts.

Closer examination reveals a spectrum ranging from entirely noninvasive to highly invasive. Within this spectrum one might rank procedures from least uncomfortable to most uncomfortable, least hazardous to most hazardous, least costly to most costly and least difficult to apply to most difficult to apply. A reasonable compromise would result in the following listing, least to most:

*-----

A few items do not fit neatly. Some measurements (e.g., thermodilution, cardiac output) piggyback on others (e.g., right-heart catheters), hence represent minimal additional invasion.

DESCRIPTIONPROCEDURE

NONINVASIVE

Inspection. Passive sensing of surface temperature, infrared emission, etc.

Auscultation, external only

Palpation, including arterial tonometry

Passive and active electrical sensing with surface electrodes such as ECG, EEG or impedance

Externally applied and sampled low-level energy such as ultrasound, light and heat

Gas sampling using skin surface probes

MINIMALLY
INVASIVE

Cutaneous needle electrodes for EEG and ECG

Cutaneous needle electrodes with stimulation for neuromuscular monitoring

Cutaneous or muscular probes for tissue temperature and gases

Abraded skin for gas sampling

IV injections and blood samples from capillaries or peripheral veins

PENETRATING

Tympanic membrane probe for temperature

Nasal septum probe for cardiovascular monitoring

Pharyngeal or esophageal probe for temperature monitoring

Esophageal probe for cardiovascular monitoring

Stomach probe for pH

	Rectal probe for temperature
	Bladder catheter for renal function
	Uterine probe for fetal monitoring
INVASIVE	Arterial catheters and probes for various purposes
	Central venous probes
	Suprapubic catheters for urine samples
HIGHLY INVASIVE	Intracardiac probes for pressures and samples
	Transcardiac probes such as pulmonary artery catheters for pressures and flows
	Subarachnoid probes for pressure
	Intracranial probes for CSF pressures or flows

The hazards of the noninvasive groups include skin irritation when energy or chemicals are applied to enhance blood flow. Burns can also occur with improper management of the electrosurgical instrument or with electrical failure in a monitor..

In the minimally invasive group, infections and bleeding are hazards. The discomfort of placing the probes is usually small but, when stimulation is used as in neuromuscular junction monitoring, discomfort can be marked.

The penetrating methods can be dangerous when they trigger reflexes (fainting), perforation or infection which is particularly common after transurethral bladder catheterization. Small plastic catheters can be inserted transcutaneously into the bladder by thrusting a long but narrow-bore needle suprapubically into the bladder and advancing the catheter, then withdrawing the needle. This invasive method is considered by some less hazardous and far less unpleasant than the penetrating methods of traditional catheterization.

Invasive methods require special skills for placing the probes. Bleeding, infection, clot formation and occlusion of the vessel lumen with subsequent ischemia in distal arteries are problems with arterial puncture. Infection, clot formation and perforation are the principal problems of central vein cannulation.

The highly invasive methods carry the highest risks. For the intra- and transcardiac probes, cardiac arrhythmias, perforation, clot formation and bleeding are the most serious hazards. The neurologic monitoring techniques with probes in the subarachnoid space or with intracranial extradural probes constitute formidable procedures, present hazards of infection and cause significant patient discomfort.

In this book we emphasize noninvasive methods of blood pressure measurements, electrocardiography and gas measurements. Some call for minimal invasions such as abrasion of the skin. In general, however, the methods described here provide the essential data and recommend themselves by reason of safe anesthesia practice, noninvasiveness and ready applicability. Some approaches presented here are not sufficiently ready for clinical use but deserve serious study because of their future promise.

Chapter 1

AUTOMATIC NONINVASIVE BLOOD PRESSURE MONITORS: WHAT IS AVAILABLE

Howard P. Apple

One of the major monitoring responsibilities in critical care areas is to measure and record the arterial blood pressure by direct or indirect means. This chapter reviews the state of the art in automatic noninvasive blood pressure instrumentation. The discussion includes occlusive techniques using auscultatory, oscillometric and palpatory methods; commercial automatic and semiautomatic units are described as to (1) specific technique/performance, (2) artifact rejection capabilities and (3) costs.

The Three Methods

Figure 1 shows a six-channel strip-chart recording demonstrating the simultaneous use of the auscultatory, oscillometric and palpatory methods. These tracings were obtained by simultaneously recording the basic transducer signals from a stethoscope/microphone, an Arteriosonde 1225, an Infrasonde 3000, a Dinamap 845 and a Datascope 865 finger pulse sensor. Various logic portions of the instruments were disabled in order to show the signals. It is important to note that blood pressure estimates were made strictly through human interpretation of the strip charts in this demonstration.