MEDICAL INTELLIGENCE

CLINICAL AND INVESTIGATIVE APPLICATION OF A NEW INSTRUMENT FOR CONTINUOUS RECORDING OF BLOOD PRESSURE AND HEART RATE*

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IN both routine hospital practice and clinical investigation, there has long been a need for an instrument that will continually record blood pressure and heart rate without discomfort to the patient.

The instrument used in the present study was designed and constructed by Gilford and his associates.[1] This "physiologic monitor" is primarily intended for use by the anesthesiologist, providing him with a continuous record of the patient's blood pressure, heart rate, respiratory rate and minute respiratory volume, at the same time freeing him

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for other and occasionally more urgent duties in the operating room. The monitor also provides an instantaneous indication of the occurrence of arrhythmia and supplies an outlet for convenient recording of the electrocardiogram. The present report is concerned with the preliminary evaluation of the blood-pressure and pulse recording components in medical ward patients.

The blood pressure is automatically measured by a modification of the conventional auscultatory method. A microphone pickup is placed over the brachial artery and covered by a standard inflatable arm cuff (Fig. 1). An air compressor slowly inflates the cuff. The first pulse beat picked up by the microphone activates a diastolic-blood-pressure indicator. Inflation of the cuff continues until the pressure within it rises to a level 10 above the last recorded pulse beat. At this level the pressure in the cuff automatically releases slowly until the first pulse beat detected by the microphone actuates the systolic-blood-pressure indicator. Pressure in the cuff is then immediately released to 0. The diastolic and systolic pressures are recorded on a Speedomax chart (Fig. 2), which can be located at any distance from the patient. The measurement cycle is repeated every three minutes.

Two safety valves, one electric and one mechanical, prevent excessive inflation of the cuff. The level of the microphone signal can be regulated by a gain control so that only true pulse beats are detected and extraneous noise occasioned by the patient's movements in bed does not influence the recording. The apparatus produces no more discomfort than manual inflation of a cuff and does not interfere with sleep.

Heart rate is measured continuously by means of an electronic circuit that times the interval between "R" waves, using standard electrocardiographic

electrodes. This information is recorded every

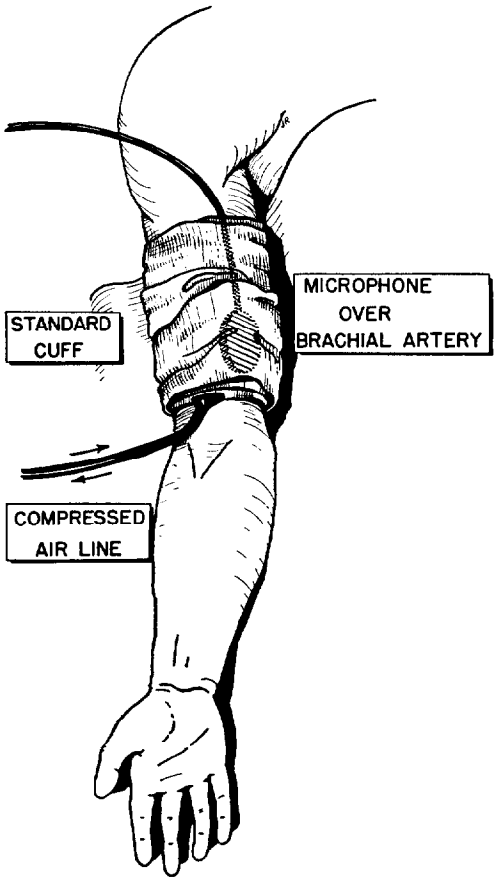

FIGURE 1. *Sketch Showing Application of the Microphone Pickup beneath a Standard Type of Pneumatic Arm Cuff.*
The skin beneath the microphone is painted with tincture of benzoin, and the microphone is fixed in place by means of adhesive tape of the elastic type ("Elastoplast") before the application of the pneumatic cuff.

thirty seconds on the Speedomax chart.

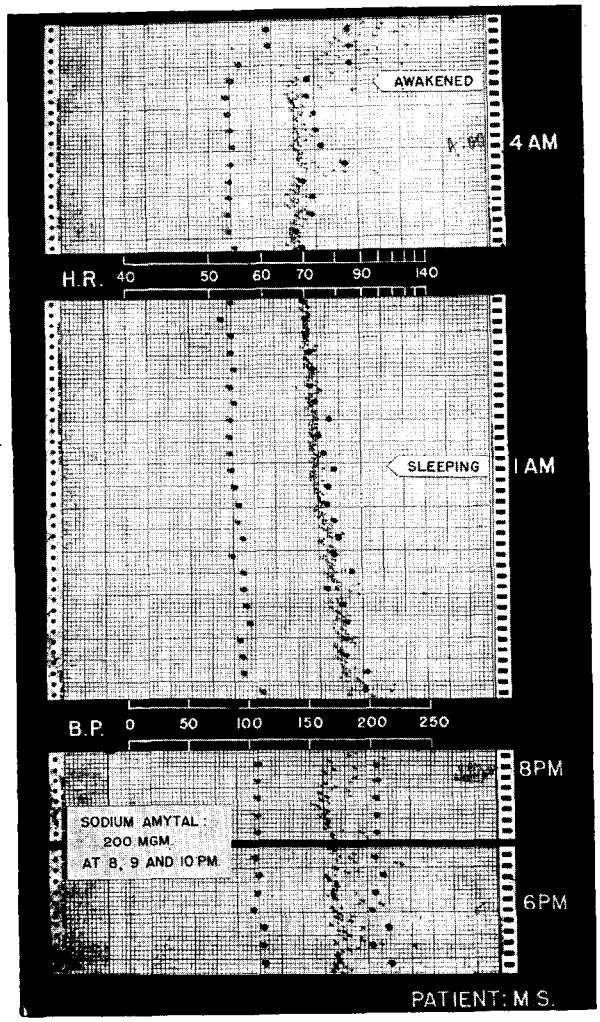

FIGURE 2. *Cuttings from the Speedomax Chart Recordings in Case 1.*

Two hundred milligrams of Sodium Amytal was administered orally at 8, 9 and 10 p.m. Systolic and diastolic pressures have been circled to make them stand out in the black-and-white illustration. (Systolic is on the right, and diastolic on the left.) The recordings not circled represent the heart rate.

On the wards this instrument has been left unattended for long periods while a printed record of blood pressure and pulse was automatically recorded. The period of continuous operation has been as long as twenty-one hours. Patients have been able to feed themselves and move about in bed.

Illustrative Cases

Twenty tests were carried out. These included 4 recordings of blood pressure and heart rate through the night during normal sleep or after the standard doses of Sodium Amytal used in the "sedation" test. Other patients included 3 with acute gastrointestinal hemorrhage, 1 with sinus tachycardia, 1 with postrenal biopsy and 11 with hypertension in whom the effects of hypotensive drugs were observed. The following cases illustrate the type of information derived from the instrument.

Case 1. M. S., a 50-year-old man with essential hypertension was given 0.2 gm. (3 gr.) of Sodium Amytal at 8, 9 and 10 p.m Recording began at 6 p.m., when the blood pressure was 215/105 and the pulse 78 (Fig. 2). The patient fell asleep and awoke during the early evening, with abrupt changes in blood pressure, but near 1 a.m. he again slept with a more gradual fall in blood pressure (Fig. 2) to a level of 160/85. He awoke 3 hours later, when the record showed an abrupt increase of blood pressure from 160/85 to 185/120 and of pulse from 68 to 76. The elevations occurred in a 5-minute period. The rapid blood-pressure changes, with falling asleep and awakening, were seen in several other cases.

Case 2. R. H., a 60-year-old man with a past history of peptic ulcer, entered the hospital because of the recent onset of hematemesis and tarry stools. Recordings began at 5 p.m., when the blood pressure was 80/50 and the pulse 75 (Fig. 3). At 5:25 p.m. the patient was given 50 mg. of Demerol subcutaneously. Three minutes later the blood pressure and pulse began to fall, and 6 minutes after the drug had been given the blood pressure was 65/40 and the pulse 52. The nurse who noted this sudden change in the record found the patient to be anxious, pale and sweaty. A transfusion of 500 cc. of blood was given, after which the blood pressure rose slowly to 110/50 and the pulse to 68. No further changes occurred for the remainder of the night.

This incident probably represented a vasovagal attack induced by the injection of Demerol in a patient who had incipient shock.

CASE 3. F. T., a 55-year-old man with essential hypertension, was under treatment with parenteral injections of hexamethonium 3 times daily. It seemed of interest to record his response to the medication. Before injection the blood pressure was stabilized at 215/130 (Fig. 4). Three minutes after subcutaneous injection of 100 mg. of hexamethonium, the blood pressure had fallen to 180/125. The maximum effect of the drug occurred 15 minutes after the administration of hexamethonium, when the blood

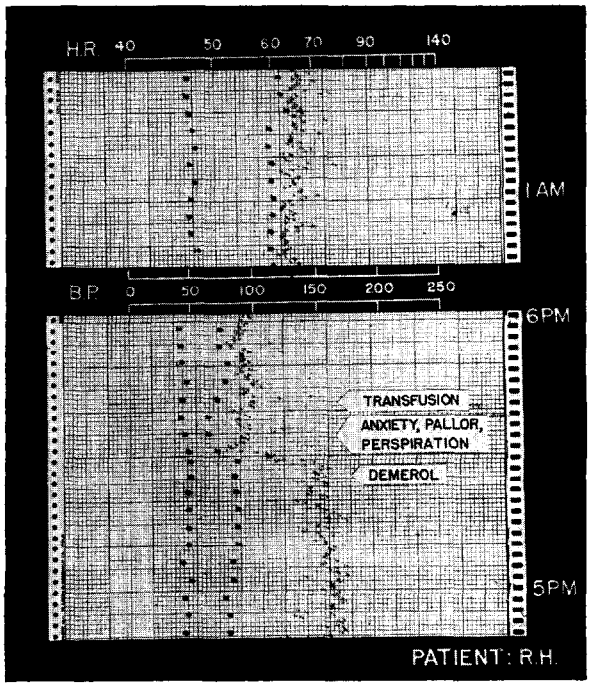

FIGURE 3. *Cuttings from the Speedomax Chart Recordings in Case 2.*
Other notations are similar to those in Figure 2.

pressure was 160/110. At 1 hour, the blood pressure was 170/125, and at 2 hours it was 185/125. At 3 hours it was 180/130, but at 4½ hours it rose to 250/130. Thus, a detailed record of the onset, degree and duration of the hypotensive effect was obtained, indicating a surprisingly rapid onset of effect and a duration of 4½ hours with the patient in the supine position.

Discussion

It should be emphasized that the instrument described above was constructed for use in anesthetized patients in the operating room. The present study explored the use of the apparatus in ward patients. A much simpler instrument would be

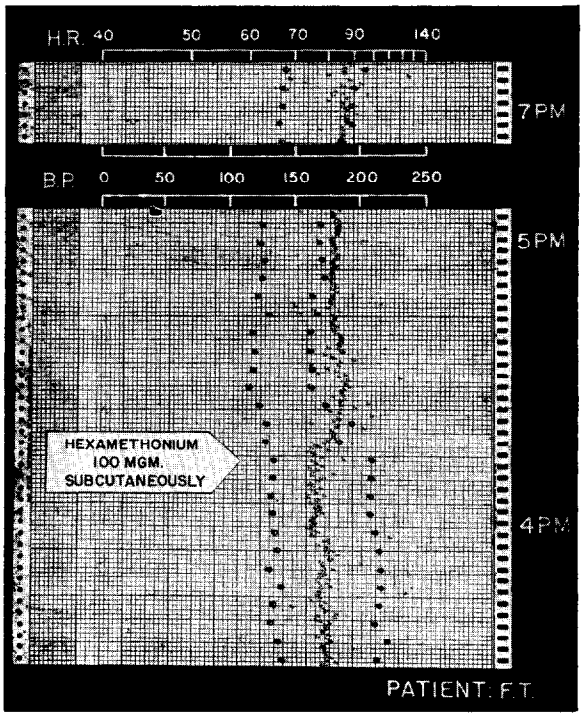

Figure 4. *Cuttings from the Speedomax Chart Recordings of Case 3.*

Other notations are similar to those given under Figure 2.

adequate for such purposes since only blood pressure and pulse were recorded.

Difficulties were occasionally encountered with the electrocardiographic leads from which the heart rate was recorded. Increased activity on the part

of the patient at times produced interference with proper recording, and the leads occasionally became loose. However, for the present purpose it seems possible that the heart rate could be recorded directly from the microphone pick-up used for determining blood pressure, thus eliminating the electrocardiograph leads.[2]

Blood-pressure measurement was attended with few difficulties. One patient complained of discomfort severe enough to require removal of the cuff. Painting of the skin under the microphone with tincture of benzoin and slight lubrication of the microphone prevented severe pressure marks on the skin during long test runs.

Our experience with the "physiologic monitor" has indicated that an instrument of this type that will provide continuous, quantitative recordings of blood pressure and pulse is of considerable value in routine hospital practice and in clinical investigation. In clinical practice remote positioning of the recorder permits the nurse to observe pressure and pulse changes from her desk in acutely ill patients. The investigator can obtain a permanent record of these physiologic variables in response to drugs or other procedures. Further developments in this type of apparatus, now in progress, should lead to instruments suitable for general hospital use.

Summary

A "physiologic monitor" for the automatic recording of a number of physiologic variables is described. Although primarily designed for operating-room use, it has been shown, by preliminary testing on the medical wards, to be useful for the blood-pressure and pulse recording in ward patients. Illustrative cases and recordings are presented.

References

1. Gilford, S. R., and Broida, H. P. *National Bureau of Standards J. Research* (in press).
2. Gilford, S. R. Unpublished data.