frequently were: (1) use of invalid code numbers, (2) reversal of patient's initials or code letters for sex and race, (3) use of incorrect dimensions for weight, and (4) failure to code emergency cases properly.

Discussion

Our main objective in developing a computer program was the acquisition of accurate information for: (1) Blue Cross and Medicare accounting purposes; (2) residents' reports for the American Board of Anesthesiology; (3) morbidity and mortality studies; (4) American Medical Association accreditation surveys; (5) guidance in departmental and hospital planning; and (6) statistical studies of environmental factors in anesthesia.

Although the program was designed to meet specific requirements, it is sufficiently flexible for other applications. Some data processing systems, which have combined the coding form and key, required the expense of special printing and were difficult to check and keypunch. Ordinarily, such a form was completed during the anesthesia. We preferred to have the anesthetist code the case after it was completed.

Alternatively, all coding could have been done by a secretary, but this was less desirable for several reasons: (1) turnover of secretaries in our department is high; (2) they do not fully comprehend anesthetic information; (3) the anesthetist usually had the time needed to code his own cases. Although most errors were eliminated by the computer system, some errors were a continual problem which was controlled only by "human" checking.

Using a computer and magnetic storage tape for data processing had several advantages over a card sorter alone: (1) cross-tabulations were more readily obtainable, (2) visual presentation of data was facilitated, (3) data cards were not subjected to damage from repeated use, and (4) less time was required to retrieve information. The major disadvantages of a computerized system were the initial time and expense involved in "debugging" programs. The annual cost of operating the program was considerably less than would be required to perform the identical functions manually.

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Nomograms for Estimation of Peripheral Resistance and Work of the Heart

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We have found it useful to measure intravascular pressures and blood flow during right-heart catheterization in patients with chronic renal failure to obtain objective indices for evaluating the course of the disease and the results of therapy, notably renal transplantation. Although cardiac output determinations are now a common procedure the calculation of useful derived parameters such as peripheral resistance is still laborious. Tables or nomograms would be useful. We therefore made three digital computer printouts of all possible values of cardiac output against all possible mean arterial pressures and the corresponding values for total peripheral resistance and left ventricular work of the heart. In addition,

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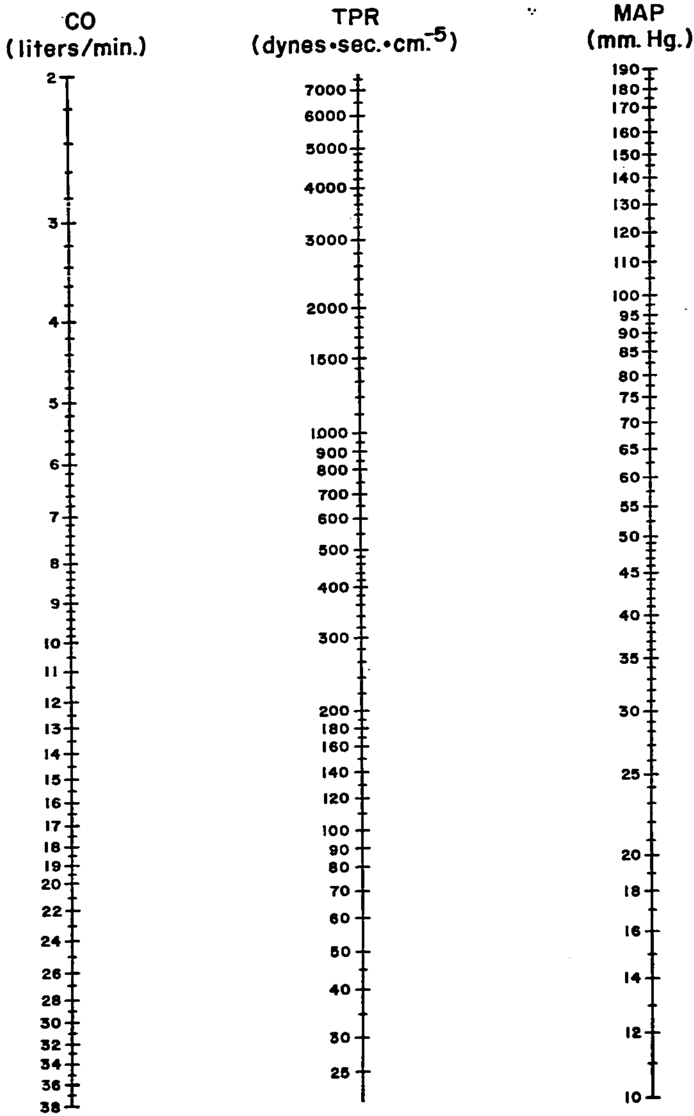

FIG. 1. Nomogram for obtaining total peripheral resistance (TPR) from cardiac output (CO) and mean arterial pressure (MAP).

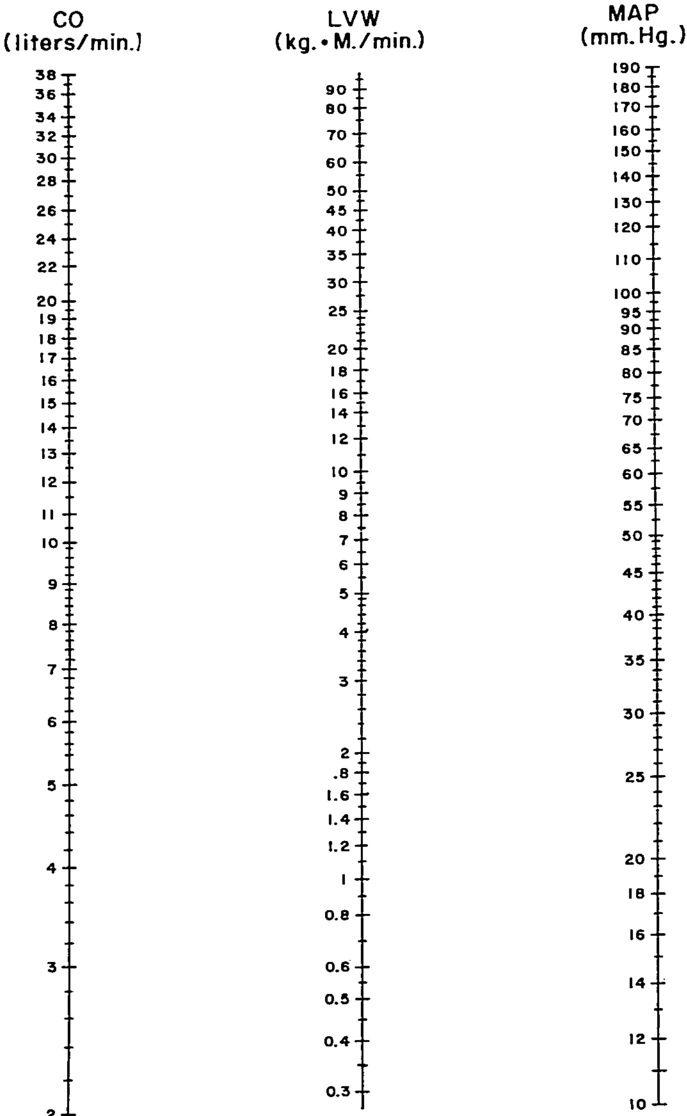

FIG. 2. Nomogram for obtaining left ventricular work (LVW) from cardiac output (CO) and mean arterial pressure (MAP).

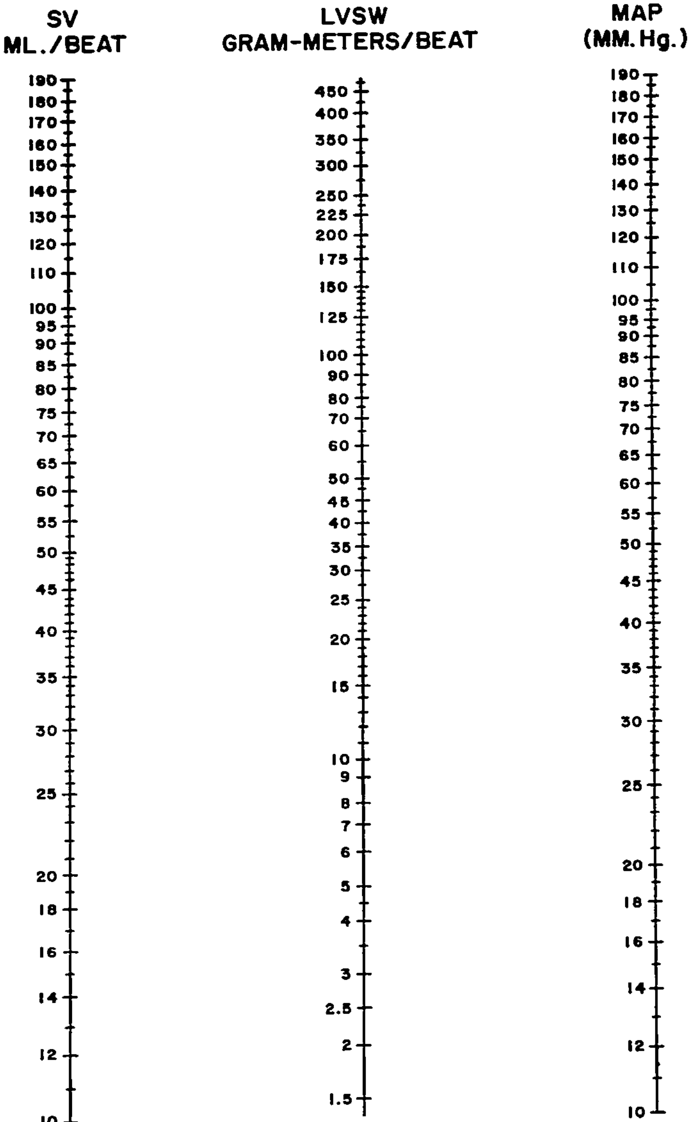

FIG. 3. Nomogram for obtaining left ventricular stroke work (LVSW) from stroke volumes (SV) and mean arterial pressure (MAP).

stroke volume and mean arterial pressure were tabulated in this manner to obtain left ventricular stroke work.

We offer these data in the form of three nomograms, pending future wider on-line access to computers.

Appendix

Formulas[1] utilized in the construction of the nomograms[2]:

(1) $$TPR_{(dynes\ sec\ cm^{-5})} = \frac{MAP_{(mm\ Hg)} \times 1332 \times 60}{CO_{(liters/min)} \times 1{,}000}$$

(2) $$LVW_{(kg\ m/min)} = 0.0135 \times CO_{(liters/min)} \times MAP_{(mm\ Hg)}$$

CO = cardiac output
TPR = total peripheral resistance
MAP = mean arterial pressure
LVW = left ventricular work

The value for total peripheral resistance (TPR) may be corrected by subtracting central venous pressure (CVP) from mean arterial pressures (MAP).[3]

(3) $$TPR_{(dynes\ sec\ cm^{-5})} = \frac{(MAP_{[mm\ Hg]} - CVP_{[mm\ Hg]}) \times 1{,}332 \times 60}{CO_{[liters/min]} \times 1{,}000}$$

Indices for TPR and LVW may be determined by substituting cardiac index (CI) for cardiac output.[3]

(4) $$CI_{(liters/min/m^2)} = \frac{CO_{(liters/min)}}{BSA_{(m^2)}}$$

where BSA = body surface area in square meters as determined by the standard Dubois nomogram.

Stroke volume (SV) is determined by dividing cardiac output (CO) by pulse rate (PR).[3]

(5) $$\text{Stroke volume}_{(ml/beat)} = \frac{\text{cardiac output}_{(liters/min)} \times 1{,}000}{\text{pulse rate}}$$

Substituting stroke volume (SV) for cardiac output in formula (2) yields the following equation.

(6) $$LVSW_{(gram\text{-}meters/beat)} = 0.0135 \times SV_{(ml/beat)} \times MAP_{(mm\ Hg)}$$

which is equivalent to:

(7) $$LVSW_{(gram\text{-}meters/beat)} = \frac{13.5 \times SV_{(ml/beat)} \times MAP_{(mm\ Hg)}}{1{,}000}$$

where LVSW = left ventricular stroke work.

An index for left ventricular stroke work may be calculated either by substituting cardiac index (CI) for cardiac output (CO) or by dividing left ventricular stroke work (LVSW) by body surface area (BSA).[4]

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