now treat *all* patients in the operating area with the same precautions. Patients are no longer designated as "HIV-positive," and all surgical specimens are handled with the same precautions.

Exposure to HIV-contaminated blood, either by needlestick or by exposure of mucous membranes or areas of dermatitis, was noted in all eight cases of seroconversion in health care workers recently reported by the CDC. Since exposure to contaminated blood is a major risk factor, all surgeons, anesthesiologists, and nurses in the O.R. wear gloves and protective eyewear for all surgical procedures, catheter insertions, and airway manipulations where exposure to blood or blood-tinged secretions is possible. All drugs are administered *via* stopcocks rather than by injection into iv ports to avoid re-capping needles. No drugs or syringes are used for more than one patient ("no needle sharing").

Since we consider every case "contaminated," we use no special supplies, and all instruments are cleaned in the same way. Re-useable equipment is scrubbed with a detergent solution, then decontaminated by soaking in glutaraldehyde solution or sodium hypochlorite solution (bleach), both of which inactivate HIV. Decontamination by steam or gas sterilization is also effective against HIV.

The current recommendations from the CDC call for "universal precautions;" that is, gloves, masks, protective eyewear, and, in some cases, gowns during procedures in which there is exposure to blood or body fluids from *any* patient. These recommendations clearly apply to the operating room. Every hospital should have its own reasoned and well-accepted policy for HIV infection control. Such a policy allows health care workers to direct their full effort toward patient care and be free from unnecessary concern for their own safety.

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A Further Note on Computer-assisted Continuous Infusion

To the Editor:—A recent paper in ANESTHESIOLOGY[1] discussed the design and implementation of a computer-assisted system which maintains plasma fentanyl concentrations at specified levels. A subsequent correspondence[2] pointed out an error in the first paper and provided expressions for the correct infusion rates. This note is a sequel to these earlier communications and is intended to give a formulation and solution of a general p-compartment infusion control problem.

We consider an open, p-compartment model in which $C(t) = (C_1(t), \ldots, C_p(t))^T$ is a vector of concentrations associated with the p-compartments. The governing equations for this system are given by

$$C'(t) = AC(t) + F(t)$$
$$C(0) \text{ given} \qquad (1)$$

where A is a $p \times p$ matrix of volume adjusted rate constants and F is a p-vector of volume normalized infusion rates.

It is assumed that target concentrations T_i are specified in the primary compartments, $1 \le i \le q < p$. We ask what infusion rates F_i must be provided to compartments $1 \le i \le q$ to maintain the given target concentrations. Equation (1) may be partitioned in the form

$$\begin{bmatrix} T'(t) \\ X'(t) \end{bmatrix} = \begin{bmatrix} A_{11}A_{12} \\ A_{21}A_{22} \end{bmatrix} \begin{bmatrix} T(t) \\ X(t) \end{bmatrix} + \begin{bmatrix} f(t) \\ 0 \end{bmatrix} \qquad (2)$$

where T is a q-vector of specified target concentrations $T_1, \ldots, T_q$; X is a $(p - q)$-vector of unknown concentrations in the auxillary compartments $q + 1 \le i \le p$; and f is a q-vector of unknown infusion rates which must be determined. The vector of zeros in the infusion rate vector reflects no input into compartments $q + 1 \le i \le p$. The matrix A is partitioned consistently; *i.e.*, A_{11} is a $q \times q$ matrix and A_{22} is a $(p - q) \times (p - q)$ matrix.

The Laplace transform formalism is essential for a concise solution. Equation (2) may be transformed by blocks to give

$$\begin{bmatrix} G_{11}G_{12} \\ G_{21}G_{22} \end{bmatrix} \begin{bmatrix} \hat{T}(s) \\ \hat{X}(s) \end{bmatrix} - \begin{bmatrix} T(0) \\ X(0) \end{bmatrix} = \begin{bmatrix} \hat{f}(s) \\ 0 \end{bmatrix} \qquad (3)$$

where G_{ij} are the corresponding submatrices of the p

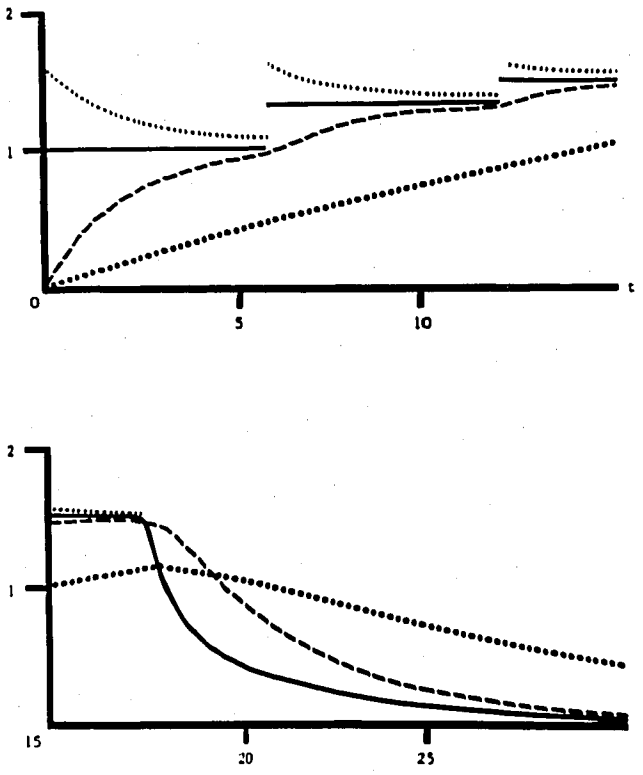

FIG. 1. Simulation of a three-compartment infusion control problem. • • • = infusion rate for compartment 1; —— = specified target concentration T_1 for compartment 1; - - - = concentration X_2 for compartment 2; • • • = concentration X_3 for compartment 3, vertical axis = concentration (arbitrary units), horizontal axis = time.

$\times$ p transfer matrix $G = sI - A$, and $\hat{T}$, $\hat{X}$, and $\hat{f}$ are the Laplace transforms of T, X, and f, respectively. Recall that the elements of $\hat{T}$ are known, while the elements of $\hat{f}$ are unknown.

Solving for the unknown infusion rates, we have

$$\hat{f}(s) = G_{11}\hat{T}(s) + G_{12}\hat{X}(s) - T(0) \qquad (4)$$

The second block of equations in (3) determines the unknown concentrations:

$$G_{21}\hat{T}(s) + G_{22}\hat{X}(s) - X(0) = 0 \qquad (5)$$

or

$$\hat{X}(s) = G_{22}^{-1}(X(0) - G_{21}\hat{T}(s)) \qquad (6)$$

Substituting (6) into (4) gives the transform of the infusion rates as

$$\hat{f}(s) = G_{11}\hat{T}(s) + G_{12}G_{22}^{-1}(X(0) - G_{21}\hat{T}(s)) - T(0)$$
$$= (G_{11} - G_{12}G_{22}^{-1}G_{21})\hat{T}(s) + G_{12}G_{22}^{-1}X(0) - T(0). \qquad (7)$$

Taking the inverse Laplace transform of (7) gives the infusion rates of f(t) required to maintain the target concentrations T(t) in compartments $1 \le i \le q$. While this is a formal solution to the problem, the components of equation (7) may be determined explicitly, at least for p of moderate size. In many cases of practical interest, q = 1 and T(t) is a constant which also simplifies the calculation. It is also interesting to note that, while the direct problem (given the infusion rates, compute the concentrations) requires the inversion of a p $\times$ p matrix, this inverse problem (given the target concentrations, compute the infusion rates) requires the inversion of a smaller submatrix.

This formulation may also be used for multiple stage procedures in which the target concentrations are changed, perhaps discontinuously. For the first stage, T(0) and X(0) represent the initial concentration in the primary and auxillary compartments, respectively. In those primary compartments in which the initial concentration is not equal to the target concentration, the resulting infusion rate will include an injection (point impulse) at t = 0.

Assume the target concentrations are changed at time $t = t_1$. At the time of transition, all compartments will have a residual drug concentration which must be included in the terms T(0) and X(0). Replacing t = 0 by $t = t_1$, the term X(0) becomes $X(t_1^-)$, the concentration in compartments $q + 1 \le i \le p$ just prior to the transition. The term T(0) becomes $T(t_1^-)$, the concentration in compartments $1 \le i \le q$ just prior to the transition.

Figure 1 shows a numerical simulation in which this method has been implemented on a three-compartment model in which a target concentration is specified in one (q = 1) primary compartment. For $0 \le t < 6$, a constant target concentration of $T_1 = 1$ is given. For $6 \le t < 12$, a target $T_1 = 4/3$ is specified and, for $12 \le t < 18$, a target $T_1 = 3/2$ is specified. For $t \ge 18$, the system is allowed to wash out. For all three stages, the infusion rate in the primary compartment is determined by equation (7). This infusion rate is then used as input to a numerical simulation of the three compartment model. The resulting concentration curves in compartments 1, 2, and 3 are also shown in the figure. The concentration in compartment 1 (labelled X_1) is clearly maintained at the specified constant target levels. The concentrations in the two auxillary compartments (labelled X_2 and X_3) are also shown. The method could be applied equally well to variable (time-dependent) target levels.

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Endotracheal Intubation Assisted with a Pencil Torch

To the Editor:—Often, during tracheal intubation, the light on the laryngoscope fails at the moment of laryngeal visualization for such reasons as poor electrical contact between the blade and the handle or bulb and electric line, a broken bulb, or a weak battery, etc. Usually, a spare laryngoscope is not available and, even if so, optimal conditions for intubation are soon lost. We have used a pencil torch in such a situation and successfully intubated the trachea (fig. 1). We have trained our residents in this technique over the past 25 yr, and it has been used by them on many occasions. We urge that this measure be a part of the intubation technique in a training program for residents.

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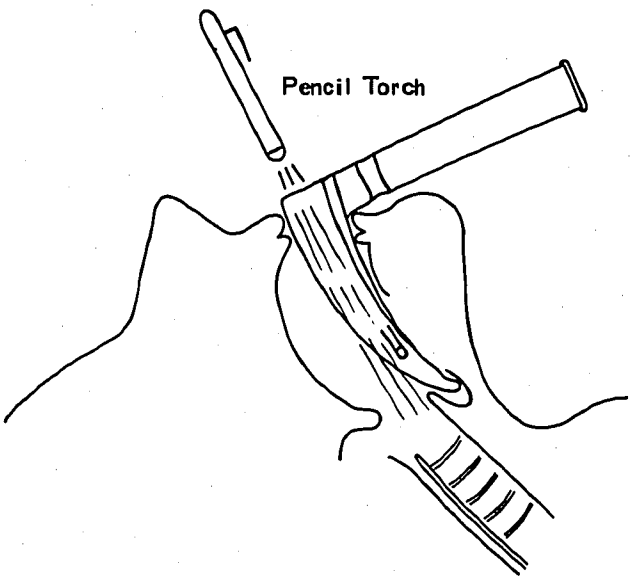

FIG. 1. An assistant holds the pencil torch and direct illumination of the vocal cords is easily accomplished.

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Nitrous Oxide and Endotracheal Tube Cuff Leaks

To the Editor:—It is well known that nitrous oxide will diffuse into and enlarge an endotracheal tube cuff.[1] Anesthesiologists are aware of the need to remove volume from the cuff as the gas within it equilibrates with the nitrous oxide tension in the blood to prevent excessive cuff pressure or volume. In a patient whose trachea remains intubated postoperatively, the reverse occurs, *i.e.*, nitrous oxide diffuses out of the cuff.

On several occasions, I have been called to the intensive care unit because of a "cuff leak," approximately 1–2 h after a patient has been transferred from the operating room. Typically the complaint is, "There must be a slow leak—we've had to keep adding air to the cuff." Injection of a few ml of air has resulted in a good seal, suggesting that the leak arose because nitrous oxide in the cuff had diffused back out. In critically ill