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1. Anesthesia personnel requirements for long-term surgeries

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Under advanced operative procedures, such as microsurgery and radical cancer surgeries, anesthesia times have become prolonged. We have recorded on a personal computer the operating room (OR) closing time and total number of overtime hours for persons who are working in the OR except anesthesia physicians. We have confirmed the present status of OR labor to make precise judgment, such as increasing personnel and shift working time.
We have eight operating tables and over thirty nurses with their assistants. Under the circumstance, there are annually 2,800 anesthesia cases with 14 attending anesthetists working daily. We calculated the data mainly with EXCEL software. We have analyzed only weekday data for the months indicated below.
The cumulative percentages and summary statistics of operating room closing times and overtime workd are summarized in Table 1.
We observed prolongation of OR closing time with some surgical procedures although the average and median closing times were minimally changed. Using a shift work schedule was effective in reducing overtime, and thus overtime payment, as shown by the reduction in overtime between 1991 and 1992.

Table 1: Summary statistics for operating room closing times.

	Cumulative percentage of closing times				
Closing time	1989 Aug/Sep	1990 Jul/Sep	1991 Jul/Sep	1992 Jul/Sep	1993 Mar/May
16:00	13.11	14.29	7.64	8.20	13.11
18:00	39.34	26.98	30.77	24.59	39.34
20:00	62.30	61.90	70.77	47.54	62.30
22:00	91.97	87.30	87.69	73.77	81.97
24:00	91.80	96.83	95.85	90.16	91.80
2:00	98.36	98.41	98.46	95.08	98.36
4:00	98.36	100.00	100.00	98.36	98.36
	Closing times				
Average	19:01	19:57	20:33	21:12	20:18
Median	18:30	20:00	20:00	21:00	19:45
St dev	0:09	0:27	2:34	3:08	3:03
n	44	64	65	61	61
	Daily overtime in minutes				
Average	1,319	1,261	1,413	954	756
Median	1,425	1,095	1,440	795	620
St dev	1,015	112	904	700	760
n	44	64	65	61	61

2. CPT—Charges Perfect Toolkit

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Administration of anesthesia billing has become increasingly complex. This is especially true for a rapidly growing, academic anesthesiology department. It can be very difficult to conform to the constantly changing rules of third party carriers in such an environment where large numbers of overlapping cases are done by various combinations of attendings, residents, and nurse anesthetists. Compliance with the reporting requirements for concurrency, alone, is enough to mandate a computerized approach to the submission of charges. Maintaining consistency in charges for the same procedure among different physicians is another important indication for a centralized, automated system as are the tasks of updating codes and analyzing data for accounting purposes.

Charges Perfect Toolkit (CPT) is an integrated program for processing anesthesiologists' charges that has been evolving within this department for over ten years. It had its beginnings on the Apple II as a replacement for simple hand calculations and delivered its output to standard billing forms that were single fed through a daisy wheel printer, one charge–one form. While still on the Apple, CPT was extended to provide menu driven choices of doctor, surgical procedure, and other routine information and was progressed to batch outputs on tractor fed, fanfold paper. In 1988, the Applesoft BASIC program and its accompanying data files were ported via modem to an IBM AT and CPT was translated to IBM's version of Microsoft BASIC. Subsequently, still undergoing modifications and expansion, CPT was converted from traditional line-numbered code to the more structured style of Microsoft QuickBASIC. It is currently being developed and compiled in the similar QBX environment of Microsoft's BASIC Professional Development System. CPT has grown to four executable modules and twelve directories. The program runs comfortably in conventional memory, but some of the functions of DOS 5.0 are required. In a minimum configuration there are about two hundred files, not counting accumulated charges data. At this time, the basic CPT system just fits on a 1.44 megabyte floppy.

Functionally, CPT allows one person to single-handedly process approximately 15,000 line items a year from raw information to data files formatted for direct upload into our institutional billing management database. The following are a few highlights of the system: (1) charge information may be entered manually, or automatically as data obtained from our operating room computer system; (2) identification of surgical procedure is followed by selection of diagnosis from a list of diagnoses cross-referenced with that procedure; (3) on-line editing of charge information is available at any time prior to concurrency determination; (4) concurrency calculations cover a forty-eight hour overlap window and are done in RAM utilizing huge arrays rather than the much slower hard drive; (5) following the concurrency routine's assignment of modifiers and calculation of charges, the charges files are converted into standard batch interface format for upload to our billing management service; (6) most recently, a "quantity assurance" routine has been added to the system that compiles monthly charge data and compares it to the operating room log to identify possible missing charges.

3. Mathematical equations and clinical practice

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The application of mathematical equations to clinical practice is sometimes not clear. For example, the theoretical relationship among cardiac output (CO), mean blood pressure (MBP) and total peripheral resistance (TPR) is CO=MBP/TPR. This equation is surely true, but it provides no guidance as to what CO we are to expect when we therapeutically intervene to change TPR, since MBP will also change. If TPR is halved, will CO double? Probably not: if the patient already has adequate flow, then his homeostatic control will not support the cardiac work required for excessive flow; however, in a patient whose flow is too low, we might expect to see a greater rise in CO. We will present examples to show that retrospectively studied populations of patients show different patterns of control.

The equations that fit retrospectively studied patients depend first on the type of patient. They also depend on what other variables are taken into account. Finally, they depend on the type of control: for example, if minute ventilation can be set freely then arterial CO_2 partial pressure will fall as ventilation rises. However, this is not what one observes in retrospective studies, since in this case ventilation is not set freely but is set by the clinical staff using

CO_2 as one of their guidelines.
There are, then, at least three types of equations: theoretical equations derived from experimental preparations in which homeostatic control is removed; retrospective studies of treated patients; and equations that would predict the effect of prospective intervention on patients.
In order to find prospective equations, one would need to study prospective data and one would need appropriate mathematical techniques. We will try to illustrate the mathematical requirements and possibilities by exploring different possible models of the control of ventilation and arterial CO_2.

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4. A computer based tutorial for transesophageal echocardiography

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Transesophageal echocardiography can provide valuable information on heart function during surgery. Interpretation of echocardiography images is a difficult skill to learn. This skill often takes months of practice under the supervision of a skilled physician teacher. This abstract describes an interactive computer based tutorial for teaching interpretation of transesophageal echocardiography images to resident anesthesiologists.
The tutorial uses video images and sounds and runs on color Apple Macintosh computers. The video and sound are digitized and played as QuickTime movies. QuickTime allows any color Macintosh computer to play real-time video images and synchronized sound without special hardware. The video images and sound are highly compressed. In most cases a single cardiac cycle is shown. The cycle is carefully constructed and played in a loop to yield a smooth, continuous motion. The use of individual loops rather than full length segments improves playback frame rate and reduces the tutorial disk space requirements. The tutorial was created with Claris HyperCard and requires both QuickTime and the HyperCard Player.
The tutorial emphasizes understanding and application of transesophageal echocardiography to anesthetic management and includes tutorial, reference, and self test sections. The tutorial is organized into sections covering major topics. Each section has several pages illustrating specific points. Each section is followed by self test questions. Residents may move sequentially page by page through the tutorial or jump from section to section. Residents may also jump directly to a glossary to see the definition of a word. A table of contents and integrated help are also included. The tutorial is self contained. Each residents can move through the tutorial at his/her own pace and without the supervision of an attending anesthesiologist.

5. Development of a real-time expert system for artificial ventilation

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The various clinical monitoring systems are, indirectly, decision aid systems for the clinician. The quantification of the physiological parameters helps the clinician to assess the physiological state of the patient. With the advent of new technology, both hardware and software, it has become possible to mimic the clinician to a large extent. The feasibility of such a system has already been demonstrated in a few research medical centers. Our aim is to provide a user-friendly rule- based expert system with minimum user interaction and which is capable of updating the rules on-line. A modular approach is used to provide flexibility in the maintenance and future extensions of the functionality of the system.
The constituent modules of the expert system are:

1. The clinical monitoring workstation modules
   - A real-time data acquisition module that collects data from the physiological monitors and the servo

ventilator at a specific rate
- Mathematical analysis modules to arrive at certain parameters that may not be available from the physiological monitors
- Maintenance of the trend of all the physiological parameters
- Display of real-time curves and other numerical parameters

2. The expert system modules
   - The knowledge base which contains the protocols/rules for controlling the ventilator under different physiological conditions
   - The data frame generator module which uses the results of the data acquisition and computational modules to formulate the current set of data (including temporal aspects of data)
   - The inference engine which is driven by the current data frame to arrive at conclusions using the knowledge base
   - The log-book module which saves the conclusions arrived by the inference engine along with the current data frame and updates the rule base if the clinician's therapy is different from the suggestions of the expert system
3. The user interface modules
   - A standard graphical user interface, the X-Windows/MOTIF is used on a real-time Posix conforming Unix-compatible operating system

The rules or protocols in the knowledge base are in simple English-like format. The format of a typical rule is as follows:

PcirvVent4: "PcirvVent4"
PcirvLungOpen and Hyperventilation and RrEqualMaximum and
  PeepEqualMaximum and pHMore 7_5
THEN
  SetPip = Pip – 1
  WinPrint (GenWin, "Check for decrease in CO_2 excretion on monitor if available");
  WinPrint (GenWin, "Lung might collapse, check the P_aO_2 line, if available");
AND TRUE: ABGWait5Minutes
PcirVent : Pressure Controlled Inverse Ratio Ventilation.
PcirvLungOpen : defined in another rule as above a certain level P_aO_2
Pip : Peak Inspiratory Pressure
ABGWait5Minutes : Wait for 5 minutes and then perform arterial blood gas analysis

The development and testing of the system, including the ventilation protocols, are done using different animal models which shortens the development time. Refinement in the animal experimental laboratory also helps to arrive at a user- friendly system that will be easily accepted in real clinical situations.

6. Adapting the heads-up anesthesia graphics monitor to assist endotracheal intubation

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The author has previously demonstrated a heads-up display that integrates various analog and digital signals from different patient monitors used in the operating room. There is a four-channel scrolling window for cardiovascular tracings and a four-channel window for respiratory data. Until now, only a single capnograph tracing is displayed in the respiratory window. This project attempts to build an intubating stylet that is guided by multiple channels of capnograms. It is named CASEI (Capnography Assisted Stylet for Endotracheal Intubation).
The prototype of CASEI is based on a disposable flexible urethroscope with a steerable head (much like a fiber-optic bronchoscope). In addition to the built-in irrigation channel, two more channels were added so that, at the tip of the scope, there are three ports capable of drawing respiratory gases. The three ports are fed to three infrared analyzers whose analog outputs are sampled by an IBM Data Acquisition Adaptor and displayed in three separate colors on the heads-up monitor in real time.

To intubate the trachea, CASEI is introduced from the mouth or a naris and is advanced towards the trachea while the capnograms are being observed on the heads-up display. Initially, all three tracings are identical and should stay identical if the stylet goes straight to the trachea. Should the tip start to deviate from the tracheal opening, one or more capnograms will start to fall off. The tip is then steered either manually or with an electromechanical servo until the three capnograms are equal again. Once the tip has entered the trachea, an endotracheal tube is slipped over the stylet in the usual manner.

7. Electronic meetings – potential for the future

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With ever increasing costs of travel and the shrinking of travel funds, new avenues of information exchange must be found to supplement traditional academic meetings. Electronic meeting methods could provide enhanced functionality of organizational groups which now must limit themselves to one meeting as a subsection of a larger group. While never replacing the large group meetings of general membership, many of the smaller satellite meetings could be held electronically. Often these smaller more specific meetings are more valuable since their focus is centered on one very specific topic. Electronic meetings could be helpful when the academician needs to attend many of these more focused meetings but has funding only for one or two and not enough time for any.
Facilities exist for electronic conferencing and may provide an opportunity for meetings that face risk of demise due to lack of attendance for reasons other than academic content. Additionally a wider audience may be served as more persons are able to attend electronically. CompuServe conferencing is one such method of interactions which may be viable for an electronic meeting. Abstracts could be submitted and reviewed in the normal fashion. Abstracts accepted would then be published in normal form. Persons would register for the meeting and designate the abstracts in which they were interested. Presenters would then create a "poster" and submit it to the meeting organizer who would then send it to those interested along with a designated discussion time. At the designated time those wishing to comment or view comments could sign on to CompuServe for a moderated discussion with the author of the work. This would also provide a complete transcript of activities.
Currently, CompuServe has many forums available on a variety of topics from gardening to Macintosh hardware support. Many of these forums have scheduled conferences where the membership can log on to a mediated question and answer period. These on-line conferences often feature notable experts on the topic being discussed.

8. Use of computer technology in academic anesthesia

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The Department of Anesthesia has successfully implemented a computer network connecting departmental personnel. Using the hospital backbone all practice areas are now a part of this network. Most broad based applications are available via the network, this method saves disk space, allows a user to move to different machines and maintain their preferred interface and makes licensing and administration easier. Applications include: Microsoft Windows, Microsoft Word for Windows, Microsoft Excel, Microsoft Mail, and OnTime Scheduling software. Faculty recruited to the Department are provided a networked IBM or compatible computer for their office and the necessary access to network resources.
Electronic mail is used for departmental communications including an external gateway to the Internet. Operating room (OR) and staff scheduling is under development and a number of faculty members are actively using OnTime personal scheduling software. The premises wiring concept provides station connections and the network runs on level 5 unshielded twisted pair. Topologies are Token-Ring 16 and 4 megabits per second and 10BaseT. Both IBM and Macintosh users have access to the network for email and file exchange. Staff can access email and do file transfers from home or any remote location. Many faculty members routinely have phone messages delivered via electronic mail. A rolling email notifier is in the anesthesia command center so faculty assigned to the OR can receive messages when convenient from the OR complex.

Plans for the future include increased integration of Internet resources, full network implementation of clinical databases such as Drug Information Source, and MEDLINE access into the operating rooms.
Recent acquisition of a BARCO computer/video projection system has revolutionized presentation of grand rounds. In addition to added presentation capabilities provided by programs such as Aldus Persuasion or Microsoft PowerPoint, the cost associated with slide making for these presentations has been eliminated. Training seminars are held weekly on a variety of topics for those wishing to learn more about computing and are lead by power users of the subject being discussed.

9. Development of a departmental local area network

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A local area network (LAN) has been installed in our Department of Anesthesiology. Users include secretaries, research technicians, and anesthesiologists. In addition to file and printer sharing, the network is used to transfer digitized video to and from remote sites at the medical center, and research data between researchers in our department and collaborators in eastern Europe *via* the Internet.
The LAN is divided into two star configurations using twisted-pair Ethernet at one site, and thin Ethernet at the other site. Both sites are connected to a medical center baseband network *via* a bridge and router. A fiber-optic cable connects two hospital buildings to New York University's main campus. Novell NetWare 3.11 is used to provide a client- server network using an IBM PS/2 Model 56 SLC server. Selected machines on the network have been assigned a TCP/IP address, which provides access to resources within the medical center, or worldwide, using the Internet.
NetWare 3.11 provides basic network functions which allow department secretaries to share printers and files. Novell LAN Workplace for DOS, version 4.01, provides access to Internet services with a terminal program (Telnet) and file transfer program (FTP). NetWare Loadable Modules allow transfer of LAN files to and from remote systems using FTP (a file-transfer protocol).
The network provides file and printer sharing. Pegasus Mail (an electronic mail-program available free of charge) and the Mercury Transport (a gateway which forwards mail to remote systems) provide all network users with access to electronic mail. A mail server allows public access to an Anesthesiology discussion group. Communication with remote mainframe computers is provided by a network terminal program (Telnet), and a file transfer program (FTP). One research group transfers data between our computers in our department and in Europe; another group moves transesophageal ultrasound images captured with a video card to a computer equipped with a Polaroid Palette slide maker. Anesthesiology residents and attending physicians can use a MEDLINE literature search system and electronic card catalog managed by the University's medical library. As part of a planned remodelling project, thin Ethernet cable is being installed in the neurosurgical operating rooms to allow remote data collection.
In conclusion, a departmental LAN provides a variety of useful services, and can be installed and maintained by an anesthesiologist.

10. Computer controlled mechanical lung model for an anesthesia simulator

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Introduction: Anesthesia simulators are educational tools that help experienced anesthesiologists and anesthesiology residents learn and practice managing common and uncommon clinical problems without risk to real patients. The purpose of the mechanical lung, the part of the simulator developed in our department, is to reproduce the airway pressure-flow characteristics of the natural lung in normal and pathophysiologic conditions arising during anesthesia. It is also able to generate an intrathoracic pressure. This last variable influences cardiac preload in the cardiovascular software model of the simulator and differs significantly for spontaneous breathing or controlled ventilation.

Materials and methods: The lung volumes are realized by mechanical bellows. The volume of the bellows is derived from an excursion sensor. An analog respiratory muscle pressure signal generated by a software model of the control of spontaneous breathing and the left and right lung excursions are inputs to the microcontroller that drives the lung. Based on these inputs, the pressures exerted by programmed nonlinear lung and thorax compliances are computed. Left and right intrapleural pressures follow from these computations. A double-acting pneumatic piston (one for each lung) then creates a force on the bellows that is equivalent to the force resulting from the intrapleural pressure, and the lung compliance on the natural lung. In this way the bellows mimics the pressure-volume (and thereby the pressure-flow) characteristics of the natural lung. The intrathoracic pressure is approximated by the mean value of the left and right pleural pressures. The microcontroller triggers prerecorded normal and abnormal left and right lung sounds synchronously to the movement of the bellows.

Clinical scenario implementation: Physiologic parameters under computer control include airway resistance, lung and thorax compliances, and intrapleural volume, allowing for the simulation of respiratory complications such as endobronchial intubation, bronchospasm, pneumothorax, and emphysema. The cardiovascular consequences of positive end expiratory pressure (PEEP) follow from the increased lung volume and intrapleural pressures.

Conclusion: The computer controlled mechanical lung model adds to the range of clinical scenarios and enhances the flexibility and realism of the simulations. New features that can be used in constructing clinical scenarios are the generation of an intrathoracic pressure and the double-acting piston that renders active expiration and coughing possible. The model enhances flexibility by bringing the pertinent physiologic parameters under computer control. Clinical scenarios can now be entirely implemented in software. Realism is improved by incorporating nonlinear compliances and by the use of a respiratory muscle pressure for the generation of different spontaneous breathing patterns.

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11. Estimation of desflurane by infrared spectroscopic monitors designed for other anesthetics

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Introduction: The utility and added safety of continuous monitoring of anesthetic vapor concentration during anesthesia has been well demonstrated. The recent introduction of the new inhalation anesthetic desflurane poses the problem that few monitors designed to report desflurane concentration are currently in hospitals. An alternative method of monitoring might prove expedient or even a cost effective alternative.
Current methods for anesthetic vapor analysis include mass spectrometry, Raman scattering detection, and infrared spectroscopy. The former two must have specific hardware alterations to read desflurane quantitatively. Infrared spectroscopy utilizes the less specific principle of transmission and absorbance of light at specific wave lengths (3.28 and 3.33 microns for desflurane) (S. Walker, Datex, 1992). Although these phenomena are known to be nonlinear and are distorted by CO_2 and water vapor, simple empiric calibration of an infrared gas monitor intended for one anesthetic might allow it to be used for estimation of desflurane concentration instead, if desflurane was known to be the sole fluorinated anesthetic present.

Method: After calibration, a Rascal (Ohmeda Model 00800–05416 Raman scattering principle monitor) was used as a "standard", and desflurane concentrations of approximately 1% through 12% were analyzed in series by the "Rascal" and by an infrared-based monitor (Ohmeda RGM 5250) which had been factory modified to read desflurane, sevoflurane, isoflurane, enflurane, and halothane. Desflurane vapor was generated from a heated flow compensated, calibrated vaporizer (Tec 6, Ohmeda) adjusted if necessary to agree with the designated "known" represented by the "Rascal" reading, and flowed in 2–8 liters/minute oxygen into the anesthesia circuit. Readings of this "known" concentration of desflurane were carried out after 5–10 minutes of stabilization on RGM settings intended for reading halothane, enflurane, isoflurane, sevoflurane, or desflurane vapor.

Results: Halothane settings for desflurane are useless because the readings, although apparently linear, exceed the highest reporting limits of the RGM before a true 2% desflurane is delivered. On the "enflurane" scale, the readings went "off scale" at only 8% desflurane. However, on the "isoflurane" scale, a true concentration up to 12% desflurane was readable by conversion. ("Sevoflurane" settings appeared to be even more useful, however, almost no monitors equipped for sevoflurane are available in hospitals today.) From 4% desflurane concentration upwards there was a linear, but increasing error in desflurane readings on all settings. Thus, by empiric substitution of "true" desflurane readings, derived from calibration with a desflurane monitor, unknown desflurane concentrations can be closely estimated on a monitor designed for isoflurane.

Discussion: The data presented here should only be taken as an indicator that the temporary use of an infrared spectrophotometric monitor calibrated for isoflurane to read desflurane concentrations may be feasible when desflurane monitors are not available. This process would require calibration of the isoflurane monitor with known desflurane vapor concentrations before use for this purpose.

Conclusion: In the absence of a specific desflurane monitor, use of an infrared spectroscopic monitor designed for isoflurane might be feasible by using the "isoflurane" setting and a nomogram for conversion to desflurane values.

Supported by the Vanderbilt Study Center for Anesthetic Toxicology.

12. Monitor controlled vaporization of desflurane

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The new inhalation anesthetic desflurane has a boiling point of 22.8 °C, which leads to practical problems in designing a vaporization system. The currently available system utilizes a heated, pressurized vaporizer, depending on sensors and internal pressure equalization valves to deliver calibrated proportions of desflurane and oxygen (Ohmeda, Tec 6, Ohmeda Medical Products). The expense of such complicated technology is considerable. This report demonstrates the possible feasibility of a simpler and less expensive vaporization and delivery system for desflurane vapor in the anesthetic range.

Method: A copper vaporization chamber salvaged from an obsolete anesthesia machine, and suitably perforated for temperature and pressure measurements was used as the vaporizer. This chamber was suitably heated by a thermostatically controlled electric heating jacket, and connected without reducing valves via a needle valve to glass/bobbin float delivery tubes originally calibrated for delivery of cyclopropane vapor in the obsolete anesthesia machine. Output of these delivery tubes was mixed with oxygen in the original anesthetic mixing chamber and the concentration of the effluent was measured continuously by an infrared spectrophotometric monitor which had been factory calibrated for desflurane (Datex Capnomac AGM- 103–27.01). Additional heating of the circuit distal to the vaporizing chamber including the metering tubes was carried out by infrared lights and maintained at approximately the same temperature as the chamber. Output of this system was measured by the monitor at several different total gas flow rates and the needle valves were adjusted to deliver the desired anesthetic concentration as indicated by the monitor. Presumed 100% desflurane vapor flow rates in the glass metering tubes were empirically assigned to the location of the bobbin float in the gas chamber during delivery of the desired anesthetic concentration at the desired flow rate.

Results: A series of initial experiments showed that "drift" downwards of observed desflurane delivery from this system at constant flow rates and settings occurred at temperatures below 32 °C in the generation chamber (presumably due to inadequate heat transfer). However, at 32 °C, concentrations remained quite stable from 30 to 600 seconds and no longer testing was carried out. Drift and variation from initial concentrations were negligible at 32 °C chamber temperature. At 32 °C and at 6 liters/minute oxygen flow rate, chamber pressure rarely exceeded 270 mmHg above ambient.

Discussion: This demonstration prototype system has many dangers and is not advocated for use in its present form. Furthermore, it is capable of producing potential lethal and hypoxic concentrations of desflurane. Nonetheless, its simplicity would presumably result in a cost reduction for the ultimate user. In its present form 100% desflurane vapor generated by "boiling" desflurane is controlled by needle valves and delivery tubes directly calibrated by an infrared spectroscopic monitor. Refinement would allow reliable calibration of the delivery system without control by the monitor.

Conclusion: We have demonstrated the feasibility of directly metered pure desflurane vapor as a source of clinical anesthetic concentrations of desflurane. This system should not be used in the clinical setting without considerable development.

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13. Computer assisted vaporization of desflurane by direct liquid injection

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Introduction: The new inhalation anesthetic, desflurane has a boiling point of 22.8 °C, which leads to practical problems in designing a vaporization system. The currently available system utilizes a heated, pressurized vaporizer depending on sensors and internal pressure equalization valves (Ohmeda, Tec 6). The expense of such complicated technology is considerable. Direct liquid desflurane injection into the circuit might be more cost effective and even possibly more maintenance free. Some clinicians are already using intermittent injections of desflurane for this purpose. We have investigated the simple alternative of constant rate direct injection of cooled liquid desflurane into the heated anesthesia breathing circuit.

Method: Desflurane was cooled in ice until needed, then transferred to a 50 milliliter glass syringe and placed in a controllable rate liquid infusion device. Crushed ice in a bag was kept on the syringe. Desflurane was infused into a "J" shaped brass tubing filled with new copper mesh placed in series with a standard heated humidifier and a standard anesthetic circuit. The infuser was kept lower than the outlet of the liquid delivery tube. Desired concentrations were calculated for each flow rate with the assumption that each milliliter of desflurane releases 207.6 milliliter desflurane vapor when fully evaporated (E.I. Eger, II, 1993). Actual concentrations of desflurane in the gas effluent from the circuit were measured at multiple calculated concentrations at 2, 4, and 8 liters/minute flow rates by an infrared spectrophotometric desflurane analyzer (Datex Capnomac AGM-103–27.01). Each change in concentration or flow rate was maintained for ten minutes or more.

Results: Stability resulted after 30 seconds at all concentrations and flows, but measured vs. calculated concentrations were as little as 2% in disagreement or as great as 30% with less error at higher flow and concentration.

Discussion: We experienced some difficulties in achieving steady state output at higher flows and concentrations until a suitable small orificial size and locations for injection into the anesthesia circuit were discovered by trial and error. Thereafter, measured and calculated concentrations maintained relatively constant for each flow and concentration. However, we have not as yet perfected the details of understanding the stable disagreement of measured and calculated concentrations. We believe the disagreements of the measured versus the calculated concentration of desflurane are probably due to reduced delivery of liquid desflurane due to mismatch of orifice size, surface tension of the desflurane, and gas flow rate. These errors might be eliminated by engineering refinement. However, an error in delivery rate by the infuser which we have not yet detected could explain the stable error.

Conclusion: The general feasibility of computer assisted constant flow cooled liquid injection system for vaporization of desflurane in anesthetic circuits is demonstrated. However, caution for clinicians already utilizing some variation of this system is suggested by our findings of error as great as 30% with our prototype system. Further engineering development is urged for this simple and inexpensive vaporization system for desflurane.

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14. A situational information management system designed to improve communications and operational efficiency in university health center surgical services

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Introduction: To reduce costs and increase operating room utilization in the surgical services of a large university medical center, a multidisciplinary task force was constituted from persons directly involved in patient care in order to investigate potential causes of low operational efficiency. In order to address this issue, a computerized communications system was developed which could track patients from presurgical admission to postsurgical disposition. A Situational Information Management System (SIMS) was jointly developed by the anesthesiology department and the graduate school of business administration. The development objectives were academic fulfillment, improved business efficiency, improved working milieu for staff, increased patient satisfaction, and statistical analysis of trends in surgical services utilization.

Methods: SIMS was created as a database with more than 40 fields of data designed to function on a distributed local area computer network. Information screens were customized for each geographical location in surgical services including admitting, same day surgery, holding area, operating suites, postanesthesia recovery area, and intensive care units based on interviews with workers. At each location, worksheets were developed which contain the data fields used by the workers at that location. The data entered at each location is site specific and owned and maintained locally. Each site of data entry and ownership has both edit and read privileges to the data. Remote peer machines have read, but not edit privileges on the same data. As the patient moves through surgical services, data, ownership and editing privileges move from location to location accompanying the patient. Data is entered, owned, and maintained by the individuals working at each geographic location in the network, but is available and displayed for all to use. SIMS was conceived primarily as a communications system but has patient and staff tracking and patient throughput analysis included.
Specific criteria were considered: the data should consist of only that which is useful to the task at hand, otherwise it will not be maintained conscientiously; the network should be peer to peer with read and edit privileges defined for all locations and users; the data base should be distributed such that malfunctions are site specific while peer locations remain unaffected; where possible software should be user- friendly click and drag; and software should be compatible with common hardware and operating systems.

Results: A model of SIMS was developed in LISP running on an IBM 486 PC platform with Windows. This prototype was used to demonstrate worksheets and information screens from different geographical locations to groups of physicians, administrators, nurses, and ancillary personnel involved in the surgical care of patients. Insight gained from these demonstrations was used to improve the design and to build support for the development of this system.