Intraoperative Non–Record-keeping Usage of Anesthesia Information Management System Workstations and Associated Hemodynamic Variability and Aberrancies

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ABSTRACT

Background: Anesthesia information management system workstations in the anesthesia workspace that allow usage of non–record-keeping applications could lead to distraction from patient care. We evaluated whether non–record-keeping usage of the computer workstation was associated with hemodynamic variability and aberrancies.

Methods: Auditing data were collected on eight anesthesia information management system workstations and linked to their corresponding electronic anesthesia records to identify which application was active at any given time during the case. For each case, the periods spent using the anesthesia information management system record-keeping module were separated from those spent using non–record-keeping applications. The variability of heart rate and blood pressure were also calculated, as were the incidence of hypotension, hypertension, and tachycardia. Analysis was performed to identify whether non–record-keeping activity was a significant predictor of these hemodynamic outcomes.

Results: Data were analyzed for 1,061 cases performed by 171 clinicians. Median (interquartile range) non–record-keeping activity time was 14 (1, 38) min, representing 16 (3, 33) % of a median 80 (39, 143) min of procedure time. Variables associated with greater non–record-keeping activity included attending anesthesiologists working unassisted, longer case duration, lower American Society of Anesthesiologists status, and general anesthesia. Overall, there was no independent association between non–record-keeping workstation use and hemodynamic variability or aberrancies during anesthesia either between cases or within cases.

Conclusion: Anesthesia providers spent sizable portions of case time performing non–record-keeping applications on anesthesia information management system workstations. This use, however, was not independently associated with greater hemodynamic variability or aberrancies in patients during maintenance of general anesthesia for predominantly general surgical and gynecologic procedures.

What We Already Know about This Topic

- Some anesthesia information management system workstations permit users to conduct non–record-keeping activities, including web browsing
- Non–record-keeping activity is potentially distracting and could compromise anesthetic care

What This Article Tells Us That Is New

- There was no association between time spent on non–record-keeping computer activities and intraoperative hemodynamic variability or aberrancies

ANESTHESIA information management systems (AIMS) have been reported to improve clinical documentation, streamline administrative processes, improve quality of care and patient safety, and facilitate both research and performance improvement.[1] Many centers have chosen to configure AIMS workstations to allow the use of other applications so as to facilitate clinical care and operations. It is unknown to what extent the presence of an "unrestricted" AIMS workstation affects computer usage patterns. Furthermore, it is unknown if such usage affects clinical outcomes since task-switching from a vigilance task to a secondary task may cause deterioration, improvement, or no change in performance of the primary task.[2–6] We tested the hypothesis that increased non-AIMS usage of the computer workstation is associated with more hemodynamic variability and hemodynamic aberrancies.

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Materials and Methods

Our large urban academic medical center has used an AIMS (CompuRecord®, Philips Medical, Andover, MA) for more than a decade, and the system is currently deployed in more than 50 anesthetizing locations. The AIMS recordkeeping module is a full-screen application in a Windows XP operating system (Microsoft, Redmond, WA) that either occupies the entire screen or may be "minimized" (hidden) to access other applications. It is also feasible for other active applications to overlay and partially or fully obscure the AIMS display. Non–record-keeping applications include use of a web browser, monitoring other anesthetizing locations, performing resident evaluations, and others. Although computer use (including Internet usage) is unrestricted, the users are bound by institutional and departmental policies regarding appropriate usage of information systems and are subject to unannounced auditing.

As a part of the departmental program for auditing the appropriateness of computer usage, we selected eight workstations in operating locations where the majority of anesthetics were performed for general and gynecologic surgery. Application monitoring software (SentryPC; Spytech Software; Canton, OH) was installed in these locations as a performance improvement measure without the knowledge of the clinical staff (and without the requirement of Institutional Review Board approval). The monitoring tool was configured to record the active (foreground) software application at any given time. Data were intermittently collected on each AIMS workstation for a period of 1 year. Retrospective analysis of the resulting collected data was approved by the Institutional Review Board (Program for Protection of Human Subjects; Mount Sinai Medical Center; New York, NY). Using identifiers and timestamps in the auditing log, the auditing data were matched to individual

Table 1. Patient, Procedure, Practitioner, and AIMS Workstation Usage Data

Data Types	Variable	Mean (SD) Median [0, 25, 75, 100 percentile] % (N)
Patient factors	Age, yr	48 (19)
	Sex (male)	39.9% (417)
	ASA physical status	
	1	18.4% (195)
	2	47.0% (499)
	3	28.3 % (300)
	4 or 5	6.2% (66)
	β-blocker history	14.3 % (152)
	Hypertension history	28.9% (307)
Anesthetic factors	Anesthetic technique	
	General	87.9% (952)
	Regional	1.9% (20)
	MAC	10.2% (108)
	Attending anesthesiologist solo	23.6% (250)
	Crystalloid/colloid administered, ml	1000 (40, 600, 2,000, 13,500)
Procedural factors	General / intraabdominal	
	Laparoscopy	30% (296)
	Laparotomy	27% (264)
	Obstetric/gynecologic	
	Intraabdominal	7% (71)
	Other	11% (112)
	Other (vascular, breast, *etc*.)	24% (233)
	Case duration, min	80 [0, 39, 143, 516]
	Estimated blood loss, ml	50 [0, 15, 150, 10,500]
Workstation usage	Non–record-keeping	
	Time, min	14 [0, 1, 38, 250]
	Percentage, %	16.0 [0, 3, 33, 90]
Hemodynamic outcomes	Hypotension (MAP < 60) epochs, #	0 [0, 0, 0, 21]
	Hypertension (MAP > 120) epochs, #	0 [0, 0, 0, 14]
	Tachycardia (pulse rate > 100) epochs, #	0 [0, 0, 9, 1,269]
	Pulse rate, SD	6.5 [0, 4.7, 8.4, 37.7]
	MAP, SD	8.6 [0, 5.8, 11.8, 30.5]

= number of epochs.

AIMS = anesthesia information management system; ASA = American Society of Anesthesiologists; MAC = monitored anesthesia care; MAP = mean arterial pressure.

computerized anesthesia records in our AIMS. Potentially confounding patient, procedure, and practitioner variables were extracted and detailed in table 1. For each case, vital signs were extracted from the "procedure start" timestamp to the "procedure finish" timestamp (or administration of glycopyrrolate, whichever came first), and all contiguous periods of non–record-keeping activity were identified during that interval.

Statistical Analysis

The SD of pulse rate was calculated as a measure of variability and the number of pulse rate recordings (acquired every 15 s) where tachycardia (heart rate >100 beats/min) occurred was tallied for each individual record-keeping and non–record-keeping period as well as for the case as a whole. For every 5-min epoch, the average mean arterial pressure (MAP; typically recorded once every 15 s from an intraarterial catheter or every 3–5 min for noninvasive blood pressure cuff) was calculated. The SD of MAP was calculated and the number of epochs with hypotension (MAP less than 60 mmHg) and hypertension (MAP greater than 120 mmHg) was tallied for each individual record-keeping and non–record-keeping period as well as for the case as a whole. Descriptive data were presented as the mean (SD) for normally distributed data, median (interquartile range) for skewed data, and N (%) for categorical data.

We tested whether the total amount of non–record-keeping activity was associated with hemodynamic aberrancies or variability over the entire case, controlling for other confounders. For group comparisons, chi-square or Fisher exact tests were used for categorical variables, Student *t* tests or ANOVA were used for normally distributed continuous variables, and nonparametric Wilcoxon rank sums or Kruskal–Wallis tests were used for nonnormally distributed continuous variables. The hemodynamic variables, all distributed nonnormally, were tested for Spearman correlation with absolute time and percentage of procedure time in which there was non–record-keeping activity. Hemodynamic aberrancies were ranked, and then rank-based stepwise regression analysis was performed to identify whether absolute or percentage of non–record-keeping activity was a significant predictor of hemodynamic aberrancies, controlling for confounders listed in table 1 as well as for attending anesthesiologist identity.

To reduce the effect of potentially confounding factors, we performed paired analyses within the same patient/case of the hemodynamic outcomes between each contiguous period of non–record-keeping activity of at least 5 min with an immediately preceding or subsequent period of record-keeping activity of at least 5 min. Event rates were calculated for each period to adjust for unequal time periods between the pairs. A minority of cases (less than 35%) had more than one pair, and for these the outcomes were averaged to create a single pair for each case. Sign-rank tests were used to test the locations of the differences between outcomes (except MAP variability, which had too few observations per period) for record-keeping and non–record-keeping periods. This procedure was then repeated after combining (rather than averaging) all the record-keeping and non–record-keeping periods for each case.

As an alternative approach, the generalized estimating equations method for repeated measurement analysis was performed to compare the hemodynamic outcomes between the record-keeping and non–record-keeping periods. Poisson regression with an offset that was the log-transformed period duration was used to compare the hypertension, hypotension, and tachycardia event rates. Because the pulsrate variability data were not normally distributed, we ranked the SD of the pulse rate within the pairs, with higher rank corresponding to greater variability. Pairs with tied ranks were excluded. Logistic regression, adjusting for duration, was then used to test the association between period effect and higher rank. Data analysis was performed with SAS v9.2 (SAS Institute Inc., Cary, NC). Two-tailed testing with significance level of *P* less than 0.05 was used.

Results

For calendar year 2010, auditing logs were collected for 1,061 cases. Table 1 tabulates descriptive statistics for data extracted for these cases. Anesthesia was provided by 68 unique attending anesthesiologists (working alone in 24% of cases), 88 residents, and 15 nurse anesthetists. Median (interquartile range) procedure time was 80 (39, 143) min. Median non–record-keeping activity time was 14 (1, 38) min, representing 16 (3, 33) % of procedure time. Individual periods of non–record-keeping activity averaged 3 (0–54) min each.

Procedures less than 1 h in duration had a significantly ($P < 0.001$) lower median percentage of non–record-keeping activity time (1%) compared with cases greater than 1 h (21% for cases 1–4 h and 29% for cases of more than 4 h.) Monitored anesthesia care cases had significantly ($P < 0.001$) less non–record-keeping activity, compared with general and regional anesthetics (medians of 0%, 17%, and 20%, respectively). Cases lasting more than 1 h with an attending working alone had a significantly greater median percentage of case time with non–record-keeping activity, compared with cases where a resident or nurse anesthetist was present (27% *vs.* 21%, respectively; $P = 0.047$). Cases of more than 1 h with patients of higher American Society of Anesthesiologists (ASA) physical status classification had less non–record-keeping activity than those of lower ASA status, with median percentage of 14 (7, 24) % for ASA of 4 or more compared with 23 (11, 39) % for ASA of 3 or lesser ($P < 0.001$).

For analysis of the association between total non–record-keeping activity and hemodynamics for each case as a whole, only general anesthesia cases (n= 890) were used, because there were few regional anesthetics, and monitored anesthesia care cases tended to have zero or very short non–record-keeping activity times. Forty-two cases with incomplete or missing data were further excluded. The relationships between hemodynamic parameters and the non–record-keeping

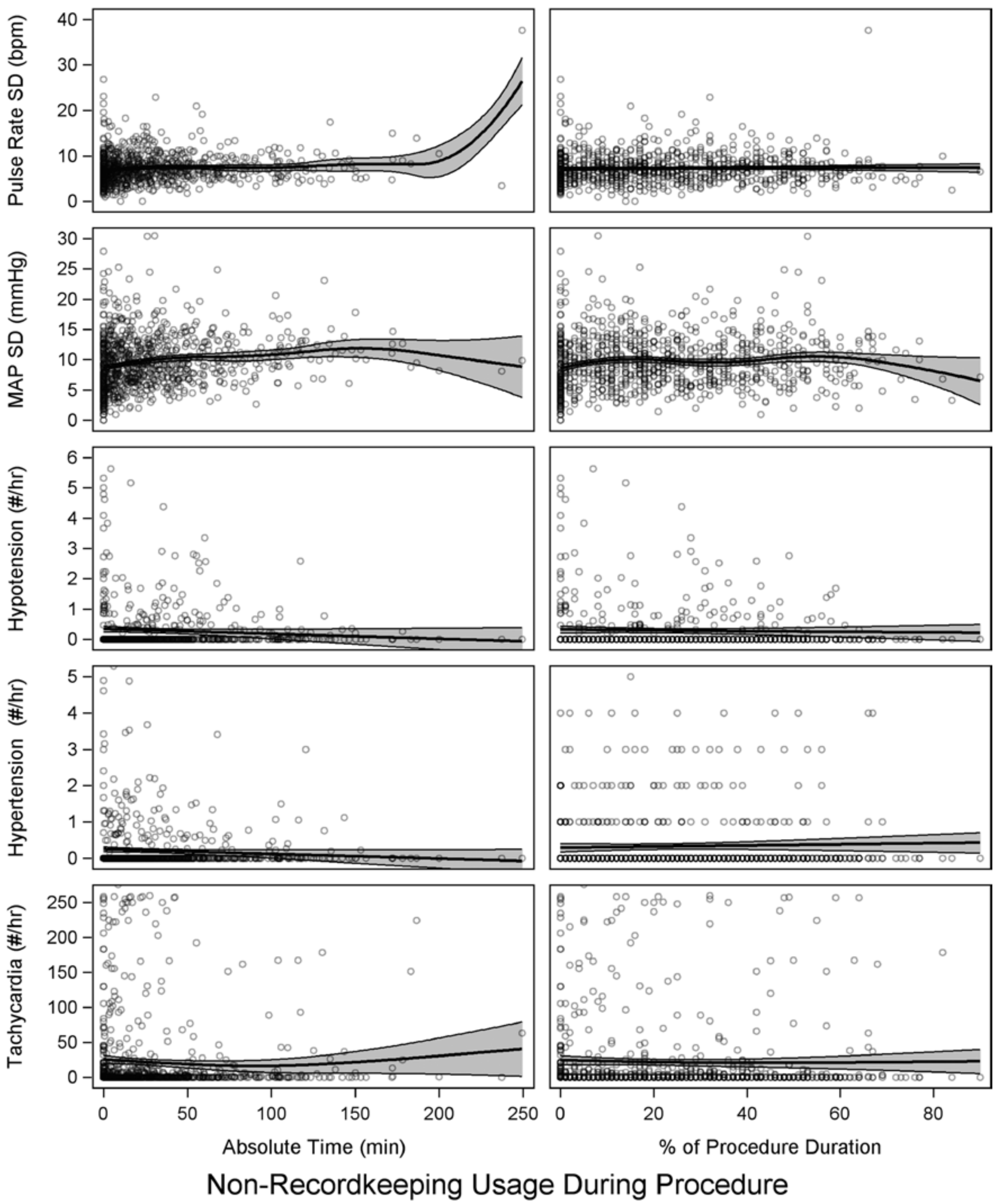

Fig. 1. Hemodynamic variables *versus* cumulative time of non–record-keeping Anesthesia Information Management System Workstation Usage. Hypotension = number of 5-min epochs with average MAP less than 60 mmHg; Hypertension = number of 5-min epochs with average MAP greater than 120 mmHg; Tachycardia = number of 15-s epochs with pulse rate greater than 100 beats/min; MAP = mean arterial pressure. The smooth curves and 95% CI were generated using penalized B-splines with three evenly spaced internal knots and 2° of the spline transformation in the SGPLOT procedure in SAS (SAS Institute, Inc. Cary, NC).

activity time as absolute time and percentage of total procedure are plotted in figure 1. Spearman correlation coefficients between hemodynamic variability or aberrancies and non–record-keeping activity time (both absolute time and percentage of total procedure) were positive but weak (all $r < 0.25$). There were no statistically significant independent associations between exposure to non–record-keeping activity (absolute or percentage) and hemodynamic variability or aberrancies, controlling for potentially confounding variables.

There were 366 pairs of recordkeeping activity followed by non–record-keeping activity of at least 5 min among 239 cases, with median durations of 9.3 min and 10.9 min,

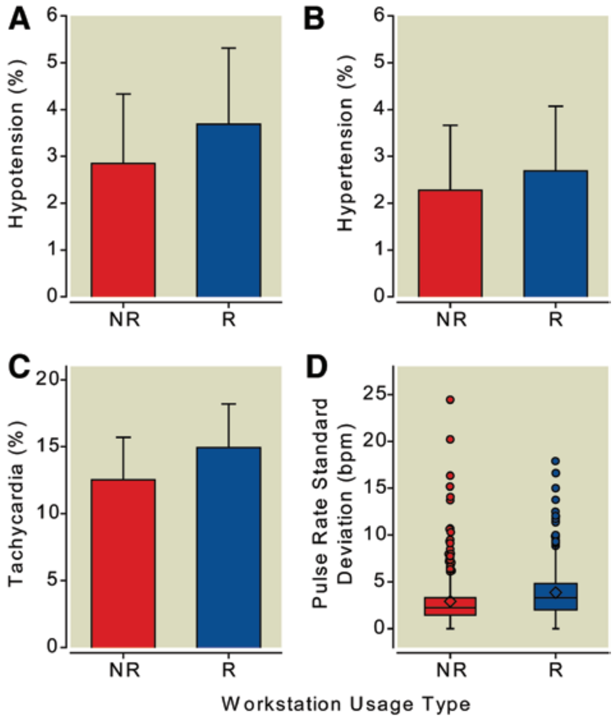

Fig. 2. Hemodynamic variables for record-keeping *versus* Non–Record-keeping Periods of Anesthesia Information Management System Workstation Usage. NR = non–record-keeping periods; R = record-keeping periods; Hypotension = proportion of cases with any 5-min epoch with average mean arterial pressure (MAP) less than 60 mmHg; Hypertension = proportion of cases with any 5-min epoch with average MAP greater than 120 mmHg; Tachycardia = proportion of cases with any 15-s epoch with pulse rate greater than 100 beats/min; *top bars* show upper limit of 95% CI around mean, except for pulse rate SD box plot, which shows median, interquartile range, and outliers. Mean is indicated by *diamond*.

respectively. There were 474 pairs of non–record-keeping followed by record-keeping of more than 5 min among 321 cases, with median durations of 13.6 and 8.7 min, respectively. The hemodynamic outcomes for all record-keeping *versus* non–record-keeping periods combined are shown in figure 2. There were no significant differences in the hypertension, hypotension, and tachycardia rates between record-keeping and non–record-keeping periods for individual pairs in either sequence, or for the case as a whole. There was a statistically significant, but clinically insignificant, increase in pulse rate variability during non–record-keeping periods compared with the record-keeping periods. The conclusion was also the same when the analysis was done using the generalized estimating equations method for repeated measures of hemodynamic outcomes.

Discussion

Our data show that anesthesia providers spent a median of 14 min (16% of procedure time) per anesthetic using non–record-keeping applications when working with Internet-connected AIMS workstations in a group of anesthetizing locations at an academic medical center. Variables associated with greater non–record-keeping activity included attending anesthesiologists working unassisted, longer case duration, lower ASA status, and general anesthesia. We found no significant association, however, between non–recordkeeping workstation use and hemodynamic variability or aberrancies between cases, or between record-keeping and non–record-keeping periods within the same case.

We are unaware of any prior reports regarding patterns of computer workstation use by anesthesiologists during anesthesia delivery, or its impact on patient care. Previous work has demonstrated that AIMS use was associated with maintenance of practitioner vigilance, compared with manual records.[7,8] A study of intraoperative reading of printed material unrelated to the case revealed that such reading occurred during anesthesia maintenance in 35% of cases, but did not affect response time to a simulated alarm.[9] An investigation that characterized anesthesia activities demonstrated that 75% of intraoperative time was spent performing secondary or indirect activities rather than observing the physiological state of the patient.[10] These findings are compatible with those in the current study. It is likely that our results are generalizable, because a majority of surveyed centers with AIMS have permitted e-mail and Internet access on AIMS workstations.[11]

This study was limited to computer usage, and did not address other nonclinical activities (*e.g.,* reading, texting, talking) that might affect performance and patient outcomes. We were also unable to determine the settings of the clinical alarms on the patient monitors or the number of practitioners present at any given time. We did not analyze time until resolution of hemodynamic perturbations for periods of record-keeping *versus* non–record-keeping activity, because very few of them occurred during intervals of non–record-keeping activity. Our auditing tool did not capture usage data sufficient to characterize the type or appropriateness of non–record-keeping activity, which could have been patient-related activities (*e.g.*, checking lab results, entering orders, reading medical literature) or nonclinical activities. Our data set also lacked sufficient sample size and data elements to assess any impact of workstation usage or hemodynamic perturbations on postoperative outcomes.

Our study did not directly assess the effects of workstation use on vigilance, because hemodynamic perturbations may occur even with the most vigilant practitioner, or may not occur even with the most distracted practitioner. We simply showed that there were no significant differences in hemodynamic variability and aberrancies (that are generally considered undesirable) associated with non–record-keeping usage of workstations. Issues of professionalism, including possible negative perceptions of others in the operating room toward anesthesia care teams' use of workstations for non–record-keeping activities, were also not addressed in this study. Others have reviewed professionalism issues related to computer and social media use.[12,13]

In summary, anesthesia providers spent sizable portions of case time performing non–record-keeping applications on AIMS workstations. This use, however, was not independently associated with greater hemodynamic variability or aberrancies in patients during maintenance of general anesthesia for predominantly general surgical and gynecologic procedures. Future work may further investigate the clinical impact of computer workstation (or other electronic device) usage, or address the appropriateness of non–record-keeping activities in an analysis of the professionalism of anesthesia care teams during patient-care activities.

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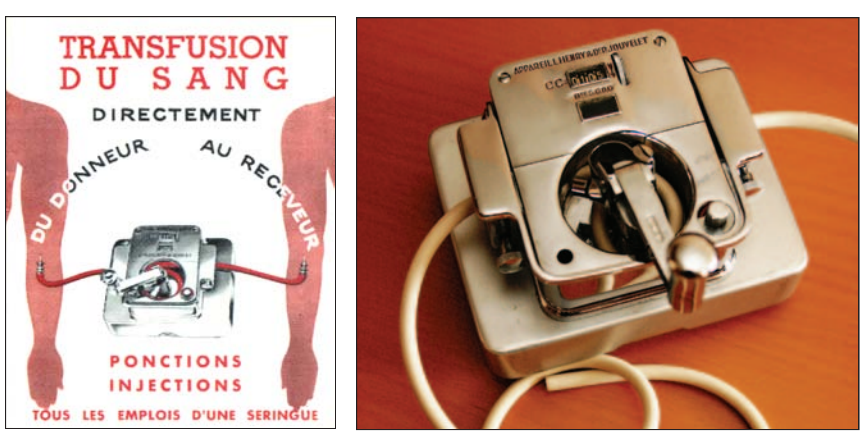
ANESTHESIOLOGY REFLECTIONS FROM THE PIERRE VIARS MUSEUM

The Henry and Jouvelet Transfusion Apparatus 1934



This apparatus was created in 1934 by Dr. P. Jouvelet and Dr. L. Henry to enable blood transfusion "from arm to arm," from the donor to the receiver. The *left panel* shows a contemporary advertisement written in French: *Blood transfusion directly from the donor to the receiver: withdrawal and injection, using a single syringe.* The risk of clotting was very limited and there was no possibility for air entry. A flow counter (in cc) provided the total amount of blood transfused. From 1950 to 1975, it was an essential tool of the French anesthesiologist in the operating room, not for direct "arm to arm" blood transfusion but as a rapid infusion and/or transfusion device. The rate depended on the manual rotation velocity through the handle. This apparatus became electrically driven but this increased the risk of air embolism when the infusion vial was empty. This is the reason why an air detection device located in the output intravenous line was introduced.

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