doi.org/10.36721/PJPS.2025.38.3.REG.13262.1

Production and application of a portable anti-loss safety medicine box

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Abstract: The production and application of a portable anti-loss safety medicine box are explored to address high loss rate of anesthetic drugs in hospitals. This study aimed to develop and evaluate efficacy of portable anti-loss safety medicine box for anesthetic drugs in hospital settings. Between June 2021 and May 2023, the study included 262 patients needing anesthesia and 56 medical staff, allocated into control (n=159) and observation (n=103) groups. The box has secure vial slots, safety alarms and locks, was tested against conventional methods of storage for three months. Analysis was done using chi-square test and t-test to determine differences in quality of management, loss of drugs and efficiency. Statistical analysis was conducted using SPSS software version 26.0. Results showed significant improvement of observation group in drug dispensing time, drug management and handover efficiency ($P<0.05$). After intervention, observation group showed better scores in issuing prescriptions, pharmacy and ward check, drug use, storage and vial recovery ($P<0.05$). No significant difference was seen in medication safety ($P>0.05$), drug loss rate was significantly lower in observation group ($P<0.05$). Portable anti-loss safety drug box enhances anesthetic drug management efficacy and safety without influencing patient care, with potential for broader hospital application compared to conventional storage.

Keywords: Portable anti-loss safety medicine box, production method, management quality, anesthesia drugs, medication safety

Submitted on 19-08-2024 – Revised on 19-01-2025 – Accepted on 28-01-2025

INTRODUCTION

Local anesthetics, which relieve pain during medical procedures, are categorized into amino esters and amino amides based on their chemical structure. This structure influences their metabolism, allergy potential and toxicity (Onal, Saltali & Apiliogullari, 2016; Taylor & McLeod, 2020). They primarily modulate voltage-gated sodium channels, with efficacy affected by lipid solubility, plasma pH and pKa. Ester-linked anesthetics have higher pKa values compared to amide-linked ones and their potency can be increased by modifying their chemical components (Martins & Destefani, 2023; Strichartz, Sanchez, Richard Arthur, Chafetz & Martiny, 1990; Garcia, 2024). Generally, these anesthetics mainly include intravenous anesthetics and inhalation anesthetics (M. Wang, Cedars, Mehta & Sarkar, 2022).

Currently, in hospitals, medical personnel place anesthetic drugs into vials and store them in boxes. Generally, an anesthetic vial consists of a vial head and a vial body, with the vial head being slightly smaller than the vial body. When anesthesiologists use anesthetic drugs, they often open the vial head and use the anesthetic drugs from the vial body (Kiatamornrak *et al*., 2022). As special drugs, anesthetic drugs are managed in hospitals with an emphasis on the accuracy of the quantity, achieving fixed quantity and fixed-point placement. After use, the anesthetic drug vials must be uniformly recycled or centrally destroyed (Khalid, Ali, Liu, Qurashi & Ali, 2022). However, the current drug boxes for storing anesthetic drugs have a high loss rate, which easily leads to the loss of individual drugs, increasing the difficulty of control (Bertaccini, 2023). Research by Xu X *et al*. indicates that the use of traditional drug boxes may lead to the loss of anesthetic drugs due to errors, causing discrepancies between the number of rescue drugs and items and the drugs issued by the pharmacy, increasing management difficulty (Xu *et al*., 2024).

In recent years, various innovations and strategies have been proposed to mitigate the loss of anesthetic drugs and improve their management. These include advanced inventory management systems, barcoding and automated dispensing cabinets (Almalki, Jambi, Elbehiry & Albuti, 2023; Mulac, Mathiesen, Taxis & Gerd Granås, 2021). Despite these advancements, challenges such as drug loss during transport and inadequate security measures during drug handling persist. The need for a robust, cost-effective solution that can be easily integrated into existing hospital workflows remains unmet. This study proposes a portable anti-loss safety medicine box designed to address these persistent challenges by providing a secure, user-friendly and efficient system for the management of anesthetic drugs (Almalki *et al*., 2023; Baryakova, Pogostin, Langer & McHugh, 2023).

The objective of this study is to develop and evaluate a portable anti-loss safety medicine box designed to address the high loss rate of anesthetic drugs and empty vials, which is a significant issue with traditional drug boxes. By exploring the production method and the practical application of this innovative medicine box, the study aims to demonstrate how it can effectively prevent drug loss,

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enhance the accuracy of drug management and improve overall safety and efficiency in medical settings.

MATERIALS AND METHODS

General data

From June 2021 to May 2023, 262 patients requiring anesthetic drugs were selected as subjects. They were divided into a control group (n=159, June 2021 to May 2022) and an observation group (n=103, June 2022 to May 2023) based on the time point. A total of 56 medical personnel were involved, including 21 males and 35 females, aged 26-53 years, with an average age of 41.49±4.63 years. The work experience ranged from 1 to 15 years, with an average of 7.81±0.84 years. There was no statistical difference in general data between the two groups (P>0.05), as shown in table 1. This study was approved by the Ethics Committee of Hangzhou Children's Hospital (Ethics Approval No: 2024-37).

Inclusion and exclusion criteria

Inclusion Criteria: (1) All cases were admitted to our hospital (Yoon *et al*., 2022) and patients required anesthetic drugs for sedation or analgesia. (2) Medical personnel were from our hospital, with a working tenure of ≥1 year. (3) Able to strictly follow the relevant requirements for the management and use of anesthetic drugs.

Exclusion criteria

(1) Patients with mental disorders or coagulation disorders. (2) Patients with severe liver and kidney dysfunction, drug contraindications, or a history of allergies. (3) Patients with cardiovascular and cerebrovascular diseases.

METHODOLOGY

Control group

In the control group, traditional anesthetic drug boxes were utilized with several measures implemented to ensure proper management of anesthetic drugs. The hospital assigned specific personnel to oversee the uniform management of these drugs, minimizing the risk of accidents and operational loopholes. Only qualified medical personnel were authorized to prescribe anesthetic drugs, ensuring their accurate and rational use. Prescriptions were issued using specialized forms that required signatures from both the prescribing physician and pharmacy personnel, with medications dispensed only after thorough verification. Additionally, prescriptions were regulated to account for appropriate timing and dosage, with injectable anesthetic drugs prescribed for no more than two days. To further reduce the risk of drug loss or omission, dedicated personnel and locked cabinets were employed as supplementary interventions (X. Wang *et al*., 2024).

Observation group

In the observation group, a portable anti-loss safety medicine box was designed, produced and applied clinically, serving as an innovative approach to anesthetic drug management.

Design and production of the portable anti-loss safety medicine box

The portable anti-loss safety medicine box consists of two main components: the vial head and lower box body, which are detachably connected. The lower box body contains multiple slots designed to securely hold anesthetic drug vial bodies. The slot diameters are engineered to permit the vial head to pass through while preventing the vial body from doing so. This design ensures that the vial body remains securely fixed in the lower box body, facilitating the proper installation and fixation of anesthetic drugs. Each drug slot in the lower box body is equipped with an elastic component that contacts the base of the vial. This mechanism allows the vial to be compressed or released under pressure, ensuring the connection between the vial body and head is securely locked. Safety locks are incorporated to prevent unauthorized access and mitigate the risk of drug loss (fig. 1).

Application of the portable anti-loss safety medicine box

(1) Prescription Code: During the patient's hospitalization, the doctor diagnoses and prescribes medication. The nurse receives the doctor's orders and the HIS (Hospital Information System) automatically generates a prescription code. (2) First Pharmacy Verification: The pharmacy prepares the medication, scans the medicine box barcode and the HIS system accurately records the drug batch. (3) Medicine Box: Medical personnel use the prescription code to retrieve the anesthetic drugs and transport them using the medicine box. (4) First Ward Verification: The nurse places the anesthetic drugs into the portable anti-loss safety medicine box, scans the box barcode and the HIS system completes the verification of the drug batch number. (5) Second Ward Verification: The dispensary conducts a second verification of the anesthetic drugs, using the HIS system to recheck the drug batch number. (6) Second Pharmacy Verification: For any remaining anesthetic drugs, the pharmacy scans the box barcode and the HIS system verifies the related drug information. Both groups completed a three-month management period.

Observation indicators

(1) Drug Dispensing, Inventory Management and Handover Time: Statistics on the drug dispensing time, operating room pharmacy anesthesia drug inventory management time and anesthesia drug handover time in the operating room pharmacy for both groups (Persad, Norton & Vitali, 2022). (2) Quality of Anesthesia Drug Management: After the intervention, the prescription issuance, pharmacy verification, ward verification, drug usage, drug storage and vial recovery for both groups were evaluated. Each item was scored out of 100, with higher scores indicating better performance (Calpin & Ffrench-

O'Carroll, 2022). (3) Medication Safety and Drug Loss Rate: Statistics on the incidence of nausea and vomiting, rash and allergies, redness and itching and diarrhea and constipation for both groups; and statistics on the incidence of anesthesia drug loss for both groups.

STATISTICAL ANALYSIS

SPSS 26.0 software was used for data processing. Chi-square ($\chi 2$) tests were conducted for count data, represented as n (%). T-tests were conducted for measurement data, represented as ($\overline{x} \pm s$). A P-value < 0.05 was considered statistically significant.

RESULTS

Comparison of drug dispensing, inventory management and handover time between the two groups

The observation group had shorter drug dispensing time, operating room pharmacy anesthesia drug inventory management time and anesthesia drug handover time in the operating room pharmacy compared to the control group (P<0.05), as shown in table 2.

Comparison of anesthesia drug management quality between the two groups

After management, the observation group had higher scores for prescription issuance, pharmacy verification, ward verification, drug usage, drug storage and vial recovery compared to the control group (P<0.05), as shown in table 3.

Comparison of medication safety and drug loss rate between the two groups

The portable anti-loss safety medicine box reduces adverse reactions considerably by enhancing the accuracy and safety of drug management. The drug container has ensured appropriate storage of the anesthetic medication from harmful factors of the environment that might disrupt their stability. Since it preserves the purity of the drugs, side effects arising from low-quality and ill-kept medication are curtailed. A major advantage of a safety medicine box is the aspect of not transmitting contaminated products of drugs by appropriate safe storage within their compartmented safe sections. This feature of design is very important for avoiding unintended drug interactions that might lead to adverse reactions. The safety medicine box also includes the scanning of a wristband on the patient to identify the patients, thus avoiding administration of medication that may have some allergies or contraindications to the patients. The safety medicine box streamlines the whole medication management process, thus lessening the workload and stress for the medical professionals, who then can focus more on the patient care without extra pressure of manually checking each step. This systematic approach not only minimizes human error but also fosters a safer environment for drug administration. As such, the use of the portable anti-loss safety medicine box effectively addresses multiple factors that may contribute to adverse reactions, making it a practical and efficient solution for improving patient safety. There was no statistical difference in medication safety between the two groups (P>0.05). The drug loss rate in the observation group was lower than that in the control group (P<0.05), as shown in table 4.

DISCUSSION

The management of anesthetic drugs not only affects the safety of a department or hospital but also impacts national security and honor (Kelly & Frerk, 2023). Both China and the international community have introduced a series of laws and regulations regarding the management of psychiatric and anesthetic drugs, making it a hot topic of research and a challenging aspect of hospital work (Gan & Wang, 2024). From procurement to patient use, psychiatric and anesthetic drugs often involve the participation of pharmacy managers, medical staff, transport personnel, patients and their families. Due to the multiple steps involved, especially in departments with high demand for anesthetic drugs such as anesthesiology and oncology, the difficulty of drug management increases (Fung & Lang, 2022). Currently, many hospitals domestically and internationally have adopted intelligent electronic medicine cabinets. However, the supervision of anesthetic drug transportation, particularly in anesthesiology departments, is insufficient and these intelligent electronic cabinets are expensive, making them difficult to promote in grassroots hospitals (Yuan *et al*., 2022). In recent years, both domestic and international inventions and research have targeted the management of anesthetic and emergency drugs, but problems such as drug loss and inconvenient transportation persist, making it difficult to ensure drug safety (Butler, Salipas & van der Rijt, 2019; Gu *et al*., 2023). Currently, intravenous anesthetic drugs are often filled in glass ampoules and then stored in plastic boxes. While this method meets the clinical need for rational use of anesthetic drugs, the loss rate of the drug vials remains high (Takahashi *et al*., 2022).

During the use of anesthetic drugs, doctors need to prescribe and sign the prescription, which is then taken by orderlies or patient family members to the pharmacy to obtain the drugs and hand them to the medical staff for verification and use. Any remaining doses require destruction by two medical staff members. The lack of dual supervision in some steps of this process and the variety of drugs involved result in a high loss rate (Chawla, Wahan, Negi, Faruk & Chawla, 2023). In this study, the observation group had shorter times for drug dispensing, operating room pharmacy anesthesia drug inventory management and anesthesia drug handover in the operating room pharmacy compared to the control group (P<0.05). After management, the observation group also scored higher in

Table 1: Comparison of general data between the two groups

General Data		Observation Group (n=103)	Control Group (n=159)	χ^2/t	P Value
Gender	Male	61 (59.22)	91 (57.23)	0.102	0.750
	Female	42 (40.78)	68 (42.77)		
Age (Years)		9.98±1.62	10.11±1.64	0.631	0.529
Weight (kg)		39.46±5.52	40.13±5.54	0.958	0.339
Height (cm)		122.14±12.19	122.21±12.21	0.045	0.964
ASA Classification	I-II	89 (57.28)	140 (54.09)	0.153	0.841
	III	14 (42.72)	19 (45.91)		
Department Source	ICU	25 (24.27)	34 (21.38)	0.299	0.585
	Orthopedics	26 (25.24)	32 (20.13)	0.950	0.330
	Ophthalmology	20 (19.42)	30 (18.87)	0.012	0.912
	Surgery	18 (17.48)	28 (17.61)	0.001	0.978
	ENT	14 (13.59)	35 (22.13)	2.915	0.088

Table 2: Comparison of drug dispensing, inventory management, and handover time between the two groups (min, $\overline{x} \pm s$)

Group	Number of Cases	Drug Dispensing Time	Operating Room Pharmacy Anesthesia Drug Inventory Management Time	Operating Room Pharmacy Anesthesia Drug Handover Time
Observation Group	56	9.52±0.73	1.41±0.51	3.32±0.52
Control Group	56	27.81±3.28	4.96±0.95	6.67±1.16
t	/	40.732	24.638	19.721
P	/	0.000	0.000	0.000

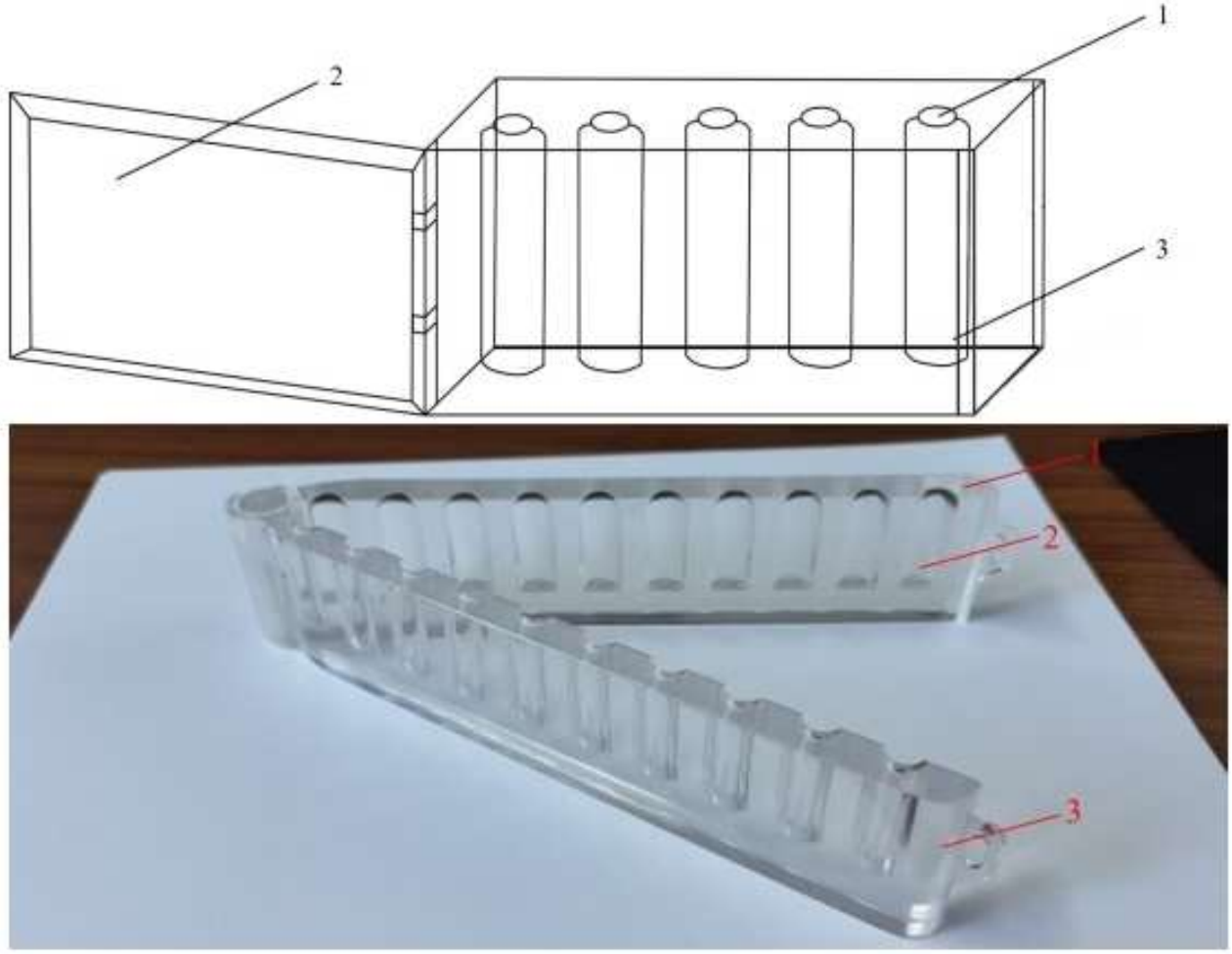
Table 3: Comparison of anesthesia drug management quality between the two groups (Score, $\overline{x} \pm s$)

Group	Number of Cases	Prescription Issuance	Pharmacy Verification	Ward Verification	Drug Usage	Drug Storage	Vial Recycle
Observation Group	56	93.41±5.35	92.15±5.23	93.24±5.42	94.43±4.39	92.25±4.31	93.61±4.32
Control Group	56	85.53±4.12	84.41±4.39	84.39±4.51	86.37±4.11	85.58±4.12	88.42±3.69
t	/	8.733	8.483	9.393	10.030	8.371	6.836
P	/	0.000	0.000	0.000	0.000	0.000	0.000

Table 4: Comparison of medication safety and drug loss rate between the two groups [n(%)]

Group	Number of Cases	Medication Safety				Incidence Rate	Drug Loss Rate
		Nausea and Vomiting	Rash and Allergy	Redness and Itching	Diarrhea and Constipation		
Observation Group	103	2(1.94)	1(0.97)	1(0.97)	2(1.94)	6(5.83)	2(1.94)
Control Group	159	3(1.89)	2(1.26)	2(1.26)	4(2.52)	11(6.92)	12(7.55)
x^2	/	/	/	/	/	0.123	3.883
P	/	/	/	/	/	0.726	0.049

prescription issuance, pharmacy verification, ward verification, drug usage, drug storage and vial recovery than the control group (P<0.05). These results indicate that the design and use of the portable anti-loss safety medicine box help shorten the time for drug dispensing, handover and inventory management, thereby improving management quality. The reasons include: the portable anti-loss safety medicine box installs the vial body in the lower box, with slots for installation and fixation, preventing the anesthetic drugs from shaking and breaking. The box can only be opened by the doctor and the pharmacy doctor, ensuring the drugs' fixation and safety during installation, preventing drug loss and improving the safety of anesthetic drug use. It also prevents the loss of vials and empty bottles, reducing the incidence of medical accidents (Chawla *et al*., 2023). In this study, there was no statistical difference in medication safety between the two groups (P>0.05), but the drug loss rate in the observation



Note: 1. Vial body partition board; 2. Box body side cover; 3. Box body

Fig. 1: Portable Anti-Loss Safety Medicine Box

group was lower than in the control group (P<0.05). These results suggest that the use of the portable anti-loss safety medicine box in anesthetic drug management does not increase the incidence of adverse reactions and reduces drug loss. The portable anti-loss safety medicine box also features a tracking and positioning label to prevent the loss of the entire box of drugs and ensure drug use within the specified time. The box includes safety locks and alarms that activate if forcibly opened (Zhao *et al*., 2024).

CONCLUSION

The study highlights the significant benefits of the portable anti-loss safety medicine box in enhancing anesthetic drug management within hospital settings. Its innovative design, featuring secure vial slots, safety locks, effectively reduces drug loss and improves overall management efficiency. Compared to traditional drug storage methods, the portable system shortens the time required for drug dispensing, inventory management and handovers, while increasing the accuracy of prescription issuance, pharmacy verification, ward checks and vial recovery. The observation group experienced a considerable reduction in drug loss, with no increase in adverse reactions. These findings support the broader adoption of the portable anti-loss safety medicine box as a practical solution for improving medication safety and operational efficiency in clinical settings.

ACKNOWLEDGMENT

The authors would like to express their gratitude to the Department of Pharmacy, Hangzhou Children's Hospital, Hangzhou, 310014, China for their invaluable support and resources throughout this study. Thank you for providing an enriching academic environment that fosters research excellence.

Conflict of interest

Authors declare no conflict of interest.

Author's contribution

These authors contributed equally to this work.

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