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Propofol Waste Reduction in the Operating Room

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Propofol is the most wasted intravenous medication used in anesthesia in the operating room (OR) (More, Dabhade, & Ghongane, 2015). Propofol, a sedative anxiolytic, is utilized as a continuous infusion in sedation procedures, or monitored anesthesia care (Nagelhout & Elisha, 2014). Inherent to these infusions is unpredictability in determining the amount of medication needed for the duration of a procedure. This project implemented customized propofol preparation charts consistent with the literature to aid the administering professional in determining the approximate milliliter requirement for the duration of a procedure. The pre-intervention steps consisted of voluntary data collection among anonymous anesthesia professionals in the OR regarding infusion characteristics. Patient weight, a commonly used infusion rate, and the duration of procedure were used in the calculation within customized charts. Post-intervention data collection was conducted in the same manner to capture the impact of the charts. This data was measured simultaneously at a local healthcare system's main hospital and separate surgery center site, and waste reduction from baseline data was found to be 49% and 60%, respectively. This project was conducted over a four-month period and translates to a potential yearly savings of greater than $15,000 for the healthcare system. A culture of waste reduction leads to savings for anesthesia departments and healthcare organizations as a whole.

Keywords

propofol, operating room, waste reduction, intravenous medication

Disciplines

Nursing | Perioperative, Operating Room and Surgical Nursing

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Abstract

Propofol is the most wasted intravenous medication used in anesthesia in the operating room (OR) (More, Dabhade, & Ghongane, 2015). Propofol, a sedative anxiolytic, is utilized as a continuous infusion in sedation procedures, or monitored anesthesia care (Nagelhout & Elisha, 2014). Inherent to these infusions is unpredictability in determining the amount of medication needed for the duration of a procedure. This project implemented customized propofol preparation charts consistent with the literature to aid the administering professional in determining the approximate milliliter requirement for the duration of a procedure. The pre-intervention steps consisted of voluntary data collection among anonymous anesthesia professionals in the OR regarding infusion characteristics. Patient weight, a commonly used infusion rate, and the duration of procedure were used in the calculation within customized charts. Post-intervention data collection was conducted in the same manner to capture the impact of the charts. This data was measured simultaneously at a local healthcare system's main hospital and separate surgery center site, and waste reduction from baseline data was found to be 49% and 60%, respectively. This project was conducted over a four-month period and translates to a potential yearly savings of greater than $15,000 for the healthcare system. A culture of waste reduction leads to savings for anesthesia departments and healthcare organizations as a whole.

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Propofol Waste Reduction in the Operating Room

Waste of intravenous medications is a global issue, costing institutions billions of dollars each year. The majority of intravenous medication waste in hospitals is attributed to common agents utilized in anesthesia care in the operating room (OR) (Dee, 2012). Propofol is consistently associated with the most waste of these medications (More et al., 2015). Factors leading to propofol waste include variable vial sizes, duration of procedures, multiple pump tubing types, and patient requirements. These factors vary in severity between institutions, but the evidence has demonstrated that reduction of propofol waste saving thousands of dollars is realistically achievable.

Implementation of customized propofol preparation charts guide the anesthesia professional in selecting the approximate number and size of propofol vials for anesthetic delivery. Specifically, these charts incorporate an institution's stocked vial sizes, predominant dosing strategy, patient weight, and the duration of the procedure. This is used to calculate the approximate milliliter (mL) requirement for any anesthetic utilizing a propofol infusion. Implementing these evidence-based charts at a local healthcare system's main hospital and surgery center has the potential to significantly reduce propofol waste and demonstrate savings consistent with the literature.

Background and Significance

Available Knowledge

Prescription drug expenditures in US hospitals have risen to more than $32 billion annually, with an estimated $1 billion in medication waste according to Toerper et al. (2014). Internationally, Canada approximates $8 billion in intravenous medication waste annually, while the United Kingdom approximates $300 million (AlSamanhodi et al., 2017). These numbers

translate to annual hospital wastage rates between 16.6% and 28.7% (Toerper et al., 2014). The

predominant reason for intravenous medication waste in the OR is the need to dispose of full or

partially full syringes by anesthesia professionals due to case completion, contamination, or

expiration (Roberman, Ahmad, & Green, 2015). It is important to note that the anesthesia drug

budget in the OR is responsible for 5-15% of a hospital's total pharmacy budget, making it a

"ripe target for decreasing waste, increasing efficiency, and improving the bottom line"

(Atcheson, Spivack, Williams, & Bryson, 2016, p. 25).

Propofol is associated with the most waste among medications administered by

anesthesia personnel in the OR (More et al., 2015). It has been reported that propofol was both

the most dispensed and wasted medication for 45% of medication waste at a surgical suite

(Mankes, 2012). Propofol is a sedative anxiolytic commonly used for the induction of general

anesthesia, as an infusion for total intravenous anesthesia (TIVA), or as a sedation infusion for

less invasive monitored anesthesia care (MAC) (Naglehout, 2014). The use of propofol infusions

for sedation is of particular significance due to difficulty in accurately gauging how much

propofol will be required. The number and size of the vials selected to prepare or add to an

existing infusion can be unpredictable due to patient differences and varying durations of

procedures. Propofol is consequently notable for as much as 51% waste of what is prepared, with

a mean waste of 5.4 mL per case (Roberman et al., 2015; Dee, 2012).

Propofol waste is less of an issue in the induction of general anesthesia because it is

typically administered at a maximum of a 20 mL bolus from one 20 mL vial. Cost rises for TIVA

cases as higher doses of propofol infusions are used to achieve general anesthesia, typically

utilizing larger vial sizes such as 50 or 100 mL (Rinehardt & Sivarajan, 2012). Sedation, or

MAC, cases pose highly variable waste data due to a lighter anesthetic plane requiring variable

dosage adjustments depending on the patient response, nature of the procedure, and remaining duration of the procedure. Time remaining in a procedure can be difficult to ascertain and leads to more waste if the professional opens another vial they may not need. MAC case waste may see the most reduction benefit through the utilization of a customized propofol preparation chart that incorporates these factors.

Two institutions, Cincinnati Children's Hospital Medical Center and Madigan Army Medical Center, implemented their own customized propofol charts in the form of a quality improvement project. Cincinnati Children's reduced its propofol waste by 50% with savings of $2,500 per month over a three-month period (Gordon & Varaghese, 2016). Madigan Army Medical Center completed a longer cycle of six months and reported median waste volume per case decline from 45.6 to 14.3 mL, or a 68% reduction (Kicker, Hill, & Matheson, 2018).

Rationale and Context

A local healthcare system was challenged with reducing its propofol waste similar to the previously discussed institutions. Its main hospital currently utilizes propofol infusions for sedation more than 4,000 times each year, with 4,225 cases between August 2018 and July 2019. This equates to at least 300 opportunities to reduce waste each month at its main campus. In addition, the healthcare system's primary surgery center was added as a second site after the medical director learned of the project at the main hospital. This surgery center performs a monthly average of over 700 surgical procedures with anesthesia and utilizes propofol infusions in 150-200 of those anesthetics. The implementation of propofol preparation charts at these sites will create ample opportunity to decrease preventable waste and increase savings.

Project Aims

The aim of this project is to decrease baseline propofol infusion waste by 50% with the implementation of the customized propofol preparation chart at two sites within a local healthcare system. Cost savings will be calculated from total waste reduction at each site. This aim is aligned with the goal of similar projects previously discussed in this paper.

Methods

Intervention

Propofol preparation charts and information sheets were placed in every OR along with extra copies in the anesthesia break room during the intervention phase. These tools were individualized to common adult weights in kilograms, dosing, and duration of procedures in minutes to guide anticipated milliliter requirement (see Figure 1 and Figure 2). These institutions supply 10, 20, and 50 mL vials of propofol, thus the milliliter requirement guided clinician judgement in vial size selection.

The customized tool was modeled after Kicker et al.'s (2018) propofol preparation charts that incorporate a 150 or 250 mcg/kg/min dosing strategy, case duration in minutes, and patient weight. Education about the tool and project goals was presented via PowerPoint to anesthesia staff at three in-person departmental meetings and via email. Data before and after implementation were collected on paper voluntarily by anonymous participation of all anesthesia professionals including physician anesthesiologists, certified registered nurse anesthetists, student registered nurse anesthetists, and anesthesia residents. The primary data recorded included the amount of propofol prepared, the amount administered, and the amount wasted in mL. Demographic data of providers was not collected to encourage participation and preserve anonymity. Thus, the data solely examined individual propofol infusion characteristics.

Study of Intervention

Data collection was conducted for a total period of 16 weeks across all ORs at the healthcare system's main hospital. Eight weeks of baseline data were collected prior to intervention implementation followed by another eight weeks after implementation. Data collection also occurred at the hospital's surgery center for ten weeks across all ORs. This data collection was for five weeks prior to and five weeks following implementation. The surgery center site was added at a later date than the main hospital, hence the difference in data collection timelines. The two sites were analyzed separately due to significantly different propofol cost between them.

This project utilized a descriptive nonequivalent posttest-only control group design. This design consists of one experimental group that receives an intervention, known as the independent variable, and one control group that receives either no intervention or a placebo. The control group, or pre-intervention period, consisted of sedation cases prior to the intervention and the experimental group, or post-intervention period, included sedation cases after implementation of the intervention. The outcome of interest was total amount of propofol wasted per procedure in mL. The study population was derived from a convenience sample during each phase of data collection. The inclusion criterion was any sedation procedure in the OR utilizing a propofol infusion as the anesthetic. Exclusion criteria were any procedure done under general anesthesia, any sedation procedure that required conversion to general anesthesia, and any sedation procedure in which the patient did not receive propofol as a continuous infusion.

Measures

This project measured one dichotomous independent variable, two continuous primary outcomes, and four additional variables. The independent variable was the placement of a chart in each OR to provide decision support to anesthesia professionals on how much propofol to

prepare in mL, with no chart present for the pre-intervention period. The primary outcomes were the amount of propofol wasted in each procedure and the cost of this wasted medication. Other variables included the amount of propofol administered, the primary propofol infusion dose, patient weight, and the duration of the procedure.

Analysis

The Shapiro-Wilk W test was used to test the normality of all continuous variables (Grove & Cipher, 2017a). The primary outcome was measured with Student's t test, also known as the independent samples t-test, if the outcome variable was parametric (Grove & Cipher, 2017b). The Mann-Whitney U test was used if the outcome variable was nonparametric (Grove & Cipher, 2017c). The independent samples t-test or Mann-Whitney U test were similarly utilized to measure whether the remaining variables were the same or significantly different between the pre-intervention and post-intervention periods.

Ethical Considerations

There were no ethical issues identified during the conduction of this project. Institutional review board exempt status for quality improvement at both the authors' university and the institution where the project was conducted was secured prior to the initiation of data collection. The authors report no conflicting interests and will not personally benefit from the outcome of the project. The authors would like to acknowledge the time taken by anesthesia personnel at both the trauma center's main hospital and its surgery center for taking the time to record data.

<center>**Results**</center>

The main hospital had a sample size of 101 and 51 cases before and after the intervention, respectively. The data for propofol waste was determined to be nonparametric both before and after the intervention based on the Shapiro Wilk test ($p = .007$ and $p < .001$,

respectively). The Mann-Whitney U test determined that there was a statistically significant difference before and after the intervention (p < .001). The main hospital had a median waste of 27 mL per case pre-intervention, with an interquartile range (IQR) of 15.3-39.6 mL wasted each case. This decreased to a median of 13.8 mL per case after the intervention, with an IQR of 4-20 mL. This represents a median savings of $3.70 per case, with an IQR of $3.16-5.49. This intervention has the potential to reduce waste in over 300 cases each month and over 4,000 cases each year, representing a possible monthly savings of $1,143 and a potential yearly savings of $15,240 based on the median difference.

The variables patient weight, primary propofol infusion dose, amount of propofol administered, and duration of the procedure were also analyzed for normality via the Shapiro Wilk test. Patient weight was the only variable determined to have a parametric distribution. There were no significant differences in these variables between the pre-intervention and post-intervention periods. These variables, as well as the sample sizes and median wastes, are presented in Table 1.

The second site, the surgery center, had a sample size of 70 and 64 cases before and after the intervention, respectively. The data for propofol waste was determined to be nonparametric for both before and after the intervention based on the Shapiro Wilk test (p < .001 for both). The Mann-Whitney U test determined that there was a statistically significant difference before and after the intervention (p = .001). The surgery center had a median waste of 10 mL per case pre-intervention, with an IQR of 0-20.3 mL wasted each case. This decreased to a median of 4 mL per case after the intervention, with an IQR of 0-8 mL. This represents a median savings of $0.19 per case, with an IQR of $0-0.39. This intervention has the potential to reduce waste in 150-200

cases each month, representing a possible monthly savings of $28.50-38 and a potential yearly

savings of $342-456 based on the median difference.

The variables patient weight, primary propofol infusion dose, amount of propofol

administered, and duration of the case were analyzed for normality via the Shapiro Wilk test.

None of the variables were determined to have a parametric distribution. There were no

significant differences between the pre-intervention and post-intervention period for patient

weight and the amount of propofol administered. The primary propofol infusion dose had a

median rate of 100 (IQR = 100-150) and 150 (IQR = 125-200) mcg/kg/min before and after the

intervention, respectively (p < .001). The median duration per case prior to the intervention was

68 minutes (IQR = 45-92.5) and 42 minutes (IQR = 30-67.5) after implementation (p < .001).

These variables, as well as sample sizes and median wastes, are presented in Table 2.

Discussion

Summary

Excessive waste of propofol in sedation procedures negatively impacts the anesthesia

medication budget and subsequently its organization. Uncertainty in preparation can be

eliminated and waste per case markedly reduced by implementing a tool that estimates the

amount of propofol needed for a procedure. The results of this project demonstrate the success of

such an intervention as a significant difference in waste was observed. Propofol preparation chart

utilization effectively reduced waste by 60% at the surgery center site, exceeding the goal of

50% waste reduction. The main hospital site nearly met the goal at 49%. This reduction

represents both a statistically and clinically significant waste reduction in comparison with other

healthcare systems reporting a reduction of 50% or higher. The main hospital site utilizes

propofol infusions for sedation cases more than 4,000 times each year and there is huge potential

for ongoing cost savings with a sustained culture change among professionals. The same applies to the surgery center site. There were no differences between observed and expected outcomes.

There was not a significant difference between any of the other pre and post variables collected at the main hospital. The surgery center did have two significant differences pre- and post-intervention. One of these variables was propofol infusion rate, which significantly increased after implementation of the intervention. The increase in propofol infusion rate may have contributed to a decrease in propofol waste by allowing propofol to be more rapidly infused, causing an increase in administration. The other variable was case duration, which significantly decreased after implementation of the intervention. The decrease in case duration may have contributed to an increase in propofol waste due to there being less time for prepared propofol to be administered during the procedure. These significant differences may have canceled each other out. Thus, it is unlikely that these differences made a significant impact on the amount of propofol wasted.

Success of the propofol preparation charts was due to the ease of creation and customization utilizing a simple table format and calculation of incremental weight ranges against time in minutes at a constant dose. The authors made two customized charts for this project based on the most common doses used by the healthcare system's professionals, 100 mcg/kg/min and 150 mcg/kg/min. These charts also have the flexibility to be adjusted for any dose and can be reproduced many times depending on the user's need. The fact that these charts were printed on paper and placed in the OR also created an ease of distribution to professionals, as well as overall low cost of implementation. Strengths of this project included the use of the two sites, an overall high level of voluntary anesthesia professional participation, and adequate sample sizes.

Interpretation

The decline in waste was comparable to similar approaches conducted at Cincinnati

Children's Hospital and Madigan Army Medical Center. The total project cycle lasted four

months, while the other studies conducted cycles of three and six months, respectively. Both of

these similar studies reported waste reduction at or exceeding the goal of 50%. An important

distinction of this project is that the authors were able to measure, replicate, and compare the

results of two sites simultaneously within one health system. This indicates the versatility and

transferability of the propofol charts in decreasing waste at any site.

Limitations

This project was not without limitations despite its success. The authors used just one

healthcare system. Another limitation arose from the use of convenience sampling rather than

random sampling for data collection. Certain professionals may have been more or less likely to

participate depending on their personal perception of waste.

Tubing type for infusion administration was another limitation, as it was not

standardized. This created variability in priming volumes with syringe pump tubing using a

priming volume of approximately 4 mL and macrodrip pump tubing using approximately 20 mL.

The project also lacked professional demographic information. This was done intentionally to

encourage anonymity and participation, yet trends among anesthesiologists, certified registered

nurse anesthetists, students, and residents could have been further evaluated.

Some difficulties arose with the paper format utilized for data collection. The paper

sheets for data collection and with the charts had the potential to be lost if thrown away or

misplaced. Any missing data could increase or decrease the calculated total waste reduction.

Weekly audits were conducted to minimize the effect of this issue. There was a small period of

time when participation slowed but subsequently increased following a department-wide email. The lack of a secure location, such as in the electronic health record for example, may have contributed to some lapses in data collection participation.

Conclusion

Propofol waste reduction directly translates to cost savings, which is a large incentive to keep this project sustainable not only in the local institution but also in any institution utilizing propofol infusions. Potential future modifications to the intervention to ensure this include modeling the propofol preparation charts directly into the electronic medical record with an interface for any dose to calculate and suggest to the provider the amount of drug needed in real time. An electronic tool could also take this a step further and suggest the best combination and quantity of differing vial sizes for quick selection. This would remain a relatively low-cost approach to saving an anesthesia department, and its institution, money that could be better utilized elsewhere.

Recommendations for research and quality improvement include conducting similar inquiry over a longer period of time to assess financial impact on a larger scale. This will create opportunities for interdisciplinary collaboration and aid in an institution's shift to Value-Based Care, or the practice of producing the best possible outcomes at the lowest possible cost (Harris, Carney, & Volpicelli, 2017). This approach could also be translated to other medications demonstrating high levels of waste in an institution with a preparation tool tailored to the drug's profile.

This project demonstrated the practicality and usefulness of the propofol preparation charts. These charts provided a simple, low cost tool to reduce waste of the highest wasted medication in the OR, propofol. Next steps include replication of the process over more cycles

and at more healthcare systems. A culture of saving can arise amongst anesthesia professionals

and their organizations by fostering awareness of current waste and the evidence that its

reduction is achievable.

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Table 1

Primary Results at the Main Hospital

Project Variables	Pre-Intervention	Post-Intervention	P-Value
Sample Size	101	51	N/A
Mean Patient Weight in kg	82	82.3	.944
Median Primary Propofol Infusion Dose in mcg/kg/min	100 [75-125]	100 [75-130]	.480
Median Amount of Propofol Administered Per Case in mL	51.7 [39.1-81.5]	50 [38-81]	.977
Median Duration of Each Case in min	72 [40-108]	60 [40-92]	.449
Median Propofol Waste Per Case in mL	27 [15.3-39.6]	13.8 [4-20]	< .001

Note. Interquartile ranges are in brackets. N/A = not applicable. P-values refer to Mann-Whitney U tests for medians and t-tests for means.

Table 2

Primary Results at the Surgery Center

Project Variables	Pre-Intervention	Post-Intervention	P Value
Sample Size	70	64	N/A
Median Patient Weight in kg	76.5 [65.2-90.7]	79.4 [67-93.8]	.572
Median Primary Propofol Infusion Dose in mcg/kg/min	100 [100-150]	150 [125-200]	< .001
Median Amount of Propofol Administered Per Case in mL	67.8 [37.3-95.5]	50 [28.8-90.8]	.140
Median Duration of Each Case in min	68 [45-92.5]	42 [30-67.5]	< 0.01
Median Propofol Waste Per Case in mL	10 [0-20.3]	4 [0-8]	.001

Note. Interquartile ranges are in parentheses. N/A = not applicable. P-values refer to Mann-Whitney U tests.

Propofol mL Requirement Utilizing a <u>100 mcg/kg/min Infusion</u>

	10 min	20 min	30 min	40 min	50 min	60 min	70 min	80 min	90 min	100 min
50 kg	5	10	15	20	25	30	35	40	45	50
55 kg	5.5	11	16.5	22	27.5	33	38.5	44	49.5	55
60 kg	6	12	18	24	30	36	42	48	54	60
65 kg	6.5	13	19.5	26	32.5	39	45.5	52	58.5	65
70 kg	7	14	21	28	35	42	49	56	63	70
75 kg	7.5	15	22.5	30	37.5	45	52.5	60	67.5	75
80 kg	8	16	24	32	40	48	56	64	72	80
85 kg	8.5	17	25.5	34	42.5	51	59.5	68	76.5	85
90 kg	9	18	27	36	45	54	63	72	81	90
95 kg	9.5	19	28.5	38	47.5	57	66.5	76	85.5	95
100 kg	10	20	30	40	50	60	70	80	90	100
110 kg	11	22	33	44	55	66	77	88	99	110
120 kg	12	24	36	48	60	72	84	96	108	120

Figure 1. Propofol preparation chart based on a propofol infusion dose of 100 mcg/kg/min.

Patient weight is listed in the leftmost column in 5 kg increments from 50 to 100 kg, then in 10-

kilogram increments from 100 to 120 kg. Time is in the topmost row in 10 min increments from

10 to 100 min. The non-bolded numbers represent the volume of propofol required in milliliters

to maintain a 100 mcg/kg/min infusion based on patient weight and time.

Propofol mL Requirement Utilizing a <u>150 mcg/kg/min Infusion</u>

	10 min	20 min	30 min	40 min	50 min	60 min	70 min	80 min	90 min	100 min
50 kg	7.5	15	22.5	30	37.5	45	52.5	60	67.5	75
55 kg	8.3	16.5	24.8	33	41.3	49.5	57.8	66	74.3	82.5
60 kg	9	18	27	36	45	54	63	72	81	90
65 kg	9.8	19.5	29.3	39	48.8	58.5	68.3	78	87.8	97.5
70 kg	10.5	21	31.5	42	52.5	63	73.5	84	94.5	105
75 kg	11.3	22.5	33.8	45	56.3	67.5	78.8	90	101.3	112.5
80 kg	12	24	36	48	60	72	84	96	108	120
85 kg	12.8	25.5	38.3	51	63.8	76.5	89.3	102	114.8	127.5
90 kg	13.5	27	40.5	54	67.5	81	94.5	108	121.5	135
95 kg	14.3	28.5	42.8	57	71.3	85.5	99.8	114	128.25	142.5
100 kg	15	30	45	60	75	90	105	120	135	150
110 kg	16.5	33	49.5	66	82.5	99	115.5	132	148.5	165
120 kg	18	36	54	72	90	108	126	144	162	180

Figure 2. Propofol preparation chart based on a propofol infusion dose of 150 mcg/kg/min.

Patient weight is listed in the leftmost column in 5 kg increments from 50 to 100 kg, then in 10

kg increments from 100 to 120 kg. Time is in the topmost row in 10 min increments from 10 to

100 min. The non-bolded numbers represent the volume of propofol required in milliliters to

maintain a 150 mcg/kg/min infusion based on patient weight and time.