Impact of staff turnover during cardiac surgical procedures

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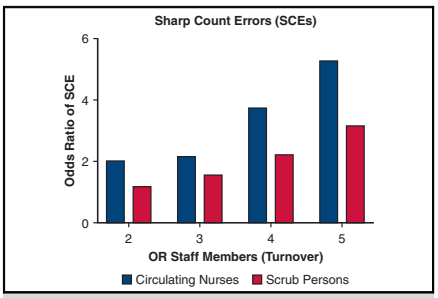
ABSTRACT

Objective: The impact of staff turnover during cardiac procedures is unknown. Accurate inventory of sharps (needles/blades) requires attention by surgical teams, and sharp count errors result in delays, can lead to retained foreign objects, and may signify communication breakdown. We hypothesized that increased team turnover raises the likelihood of sharp count errors and may negatively affect patient outcomes.

Methods: All cardiac operations performed at our institution from May 2011 to March 2016 were reviewed for sharp count errors from a prospectively maintained database. Univariate and multivariable analyses were performed.

Results: Among 7264 consecutive cardiac operations, sharp count errors occurred in 723 cases (10%). There were no retained sharps detected by x-ray in our series. Sharp count errors were lower on first start cases (7.7% vs 10.7%, $P < .001$). Cases with sharp count errors were longer than those without (7 vs 5.7 hours, $P < .001$). In multivariable analysis, factors associated with an increase in sharp count errors were non–first start cases (odds ratio [OR], 1.3; $P = .006$), weekend cases (OR, 1.6; $P < .004$), more than 2 scrub personnel (3 scrubs: OR, 1.3; $P = .032$; 4 scrubs: OR, 2; $P < .001$; 5 scrubs: OR, 2.4; $P = .004$), and more than 1 circulating nurse (2 nurses: OR, 1.9; $P < .001$; 3 nurses: OR, 2; $P < .001$; 4 nurses: OR, 2.4; $P < .001$; 5 nurses: OR, 3.1; $P < .001$). Sharp count errors were associated with higher rates of in-hospital mortality (OR, 1.9; $P = .038$).

Conclusions: Sharp count errors are more prevalent with increased team turnover and during non–first start cases or weekends. Sharp count errors may be a surrogate marker for other errors and thus increased mortality. Reducing intraoperative team turnover or optimizing hand-offs may reduce sharp count errors. (J Thorac Cardiovasc Surg 2021;161:139-44)



Likelihood of SCEs based on operating staff turnover.

CENTRAL MESSAGE

SCEs in the cardiac operating room are more likely with increased nursing and scrub personnel turnover.

PERSPECTIVE

Team turnover, resulting in transitions of care between providers, has been consistently shown to be a critically high-risk time for error. This article highlights the imperative need to minimize turnover and educate all team members on safe transition practices to improve the quality of care and decrease error in the operating room.

See Commentaries on pages 145, 146, and 147.

Cardiac surgery operations can be long, are technically complex, and require collaboration from a large multidisciplinary team to be safely executed. In addition to the

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Abbreviations and Acronyms
CN = circulating nurse
OR = odds ratio
SCE = sharp count error
SP = scrub person
STS = Society of Thoracic Surgeons

surgeon(s), this team includes anesthesia providers, perfusionists, physician assistants, nurses, scrub personnel, and their respective trainees. Aside from the surgeon(s), it is common for all team members to undergo multiple substitutions during the course of an operation for breaks and shift changes. These transitions in care can lead to adverse events if not performed properly.[1,2]

With growing concern on the impact of long hours and physician fatigue on patient safety and outcomes, work hour restrictions are now imposed on physicians, which has inherently increased the number of care transitions between providers. For physicians, significant work has been done to improve the quality of the hand-off between providers when personnel changes are necessary.[3,4] Other members of the intraoperative support team may receive less vigorous training, and at many institutions there are no protocols or standards governing their information exchange.

To examine the impact of personnel changes on error frequency, we used the routine practice of sharps inventory done between the circulating nurse (CN) and the scrub person (SP). Accurate inventory of sharps (needles/blades) requires attention by surgical teams. Errors in counting are costly and result in significant time delays because patients must undergo extra imaging and additional time in the operating room for retained foreign objects. Moreover, such errors may signify propensity for other unmeasured errors. We hypothesized that more team turnover during a case would be associated with more count errors. We further investigated whether there was an association between sharp count errors (SCEs) and patient outcomes.

MATERIALS AND METHODS

Patient Selection and Data Collection

This study was reviewed by the Partners Human Research Committee's Institutional Review Board for human research and found to be exempt. A prospective longitudinal operating room database was compiled for all patients undergoing cardiac operations at the Massachusetts General Hospital from May 2011 to March 2016. All cases were performed at the Massachusetts General Hospital main campus.

Sharp Inventory Practice

Our hospital follows the Association of periOperative Registered Nurses guidelines on sharp counting (Figure 1). Before patient entry into the operating room, a count is completed, which includes instruments, sharps, and sponges. The numbers are documented on a paper record (Figure 2). During the operation, when additional instruments, sharps, and sponges are needed, they are opened onto the sterile field and documented on the record by the CN. The discarded sharps are collected in prefabricated collection devices. When closing is initiated, an initial closing count is conducted to ensure the numbers match. The final count is completed after the incision is closed. If there is a discrepancy on the final count, an exhaustive search is completed for the missing item. Typically, multiple additional staff members are asked to come into the operating room and assist with the search. If the count is not corrected, flat plate radiographs of the patient are taken to exonerate the operative field. The patient remains on the operating room table, fully anesthetized with the sterile field intact until one of the surgeons speaks directly with an attending radiologist to discuss the results of the radiograph. The added time spent in the operating room varies but is significant. Despite this added time, we continue to follow Association of periOperative Registered Nurses guidelines for sharps inventory and reconciliation of count discrepancies.

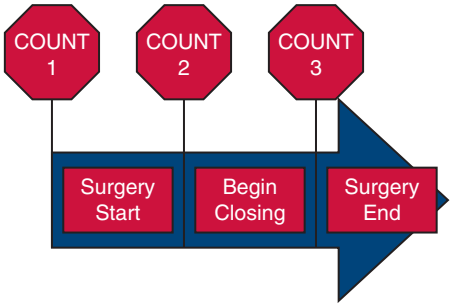

FIGURE 1. The standard operating room counting procedure is shown. A preliminary count is performed before the patient enters the operating room (count 1). Next, an initial closing count (count 2) is performed when closing is initiated. A final count (count 3) is completed after the incision is completely closed.

Statistical Analysis

All statistical analysis was performed with Stata/MP 15.0 (StataCorp LP, College Station, Tex). Normally distributed continuous data were expressed as means with standard deviations, and non-normally distributed data were expressed as medians with interquartile ranges. Categoric data were expressed as numbers and percentages. A Student *t* test or Wilcoxon rank-sum test was used where appropriate for continuous variables, and a chi-square test was used for categoric variables. All tests were performed 2-sided. Normality of the data was assessed using histograms, skewness, kurtosis, or the Shapiro–Wilk test. A univariate screen was performed on the basis of predictors that we hypothesized would be significant. These predictors were then used in a logistic regression model. Both the number of CNs and SPs were coded as factor variables with one as the reference group.

RESULTS

There were 7264 consecutive cardiac operations performed during the study period. Unadjusted comparisons are shown in Table 1. SCEs occurred in 723 cases (10%). Cases with SCEs were significantly longer than those without (7 vs 5.7 hours, $P < .001$). SCE rates were similar on weekends (9.9% vs 12%, $P = .161$) and lower on first start cases (7.7% vs 10.7%, $P < .001$). On average, there were more CNs and SPs (thus more operating room staff turnover) involved in cases with SCEs (3.1 vs 2.7 and 2.3 vs 2, $P < .001$). Finally, there was a trend toward more

Cardiac-Vascular Worksheet

Sponges

10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200

Laparotomy Pads

5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200

Blades

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Needles

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220
221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260

Miscellaneous Items:

Bovie Tips	Scratch Pads	Fred	Fogarty Inserts	Store String	Shoe Lace	Tournies	Shods	Hypos
Bull Dogs	Shunts	Peanuts	Vessel Loops	Hemoclip	Marks Needles	Saphenous Vein Cannula	Pump Catheter	**Intraop Packing**
								Throat Packing
								☐ IN ☐ OUT

FIGURE 2. Paper inventory form for tracking sponges, laparotomy pads, and sharps (blades and needles) and miscellaneous items.

SCEs during emergency cases compared with elective cases (12.3% vs 10.7%, $P = .059$).

In multivariable analysis (Table 2, Figure 3), factors associated with a significant increase in SCEs were non–first start cases (odds ratio [OR], 1.3; $P = .006$), weekend cases (OR, 1.6; $P < .004$), more than 2 scrub personnel turnovers (3 scrubs: OR, 1.3, $P = .032$; 4 scrubs: OR, 2, $P < .001$; 5 scrubs: OR, 2.4, $P = .004$), and more than 1 CN turnover

TABLE 1. Univariate comparison of cases with and without sharp count errors

Variable	SCE 723 (10)	No SCE 6541 (90)	*P* value
Case length, h	7 (3)	5.7 (2.6)	<.001
Day of week			
Weekend	46 (12)	336 (88)	.161
Weekday	677 (9.9)	6205 (90.2)	.161
Start timing			
First start cases	135 (7.7)	1610 (92.3)	<.001
Non–first start cases	588 (10.7)	4931 (89.4)	<.001
CNs	3.1 (1.1)	2.7 (1.1)	<.001
1	47 (4.8)	938 (95.23)	<.001
2	179 (8.9)	1837 (91.1)	<.001
3	244 (9.9)	2220 (90.1)	<.001
4	167 (12.7)	1145 (87.3)	<.001
5	83 (17.8)	384 (82.2)	<.001
SPs	2.3 (1)	2 (0.9)	<.001
1	173 (7.4)	2178 (92.6)	<.001
2	281 (9.5)	2685 (90.5)	<.001
3	172 (12)	1260 (88)	<.001
4	74 (18)	337 (82)	<.001
5	17 (22.4)	59 (77.6)	<.001
Case status			
Urgent/emergency	297 (12.3)	2113 (87.7)	.059
Elective	353 (10.7)	2941 (89.3)	.059

Values are n (%) or mean (standard deviation). *SCE*, Sharp count error; *CN*, circulating nurse; *SP*, scrub person.

(2 nurses: OR, 1.9, $P < .001$; 3 nurses: OR, 2, $P < .001$; 4 nurses: OR, 2.4, $P < .001$; 5 nurses: OR, 3.1, $P < .001$).

To examine the association of SCE on outcomes, we examined a subset of Society of Thoracic Surgeons (STS) indexed patients with complete demographic data (n = 5713). In this population, there were 650 (11.4%) SCEs and 246 (4.3%) mortalities. SCEs were present in 21.5% of patients who died versus 10.9% of patients who survived ($P < .001$). There was a significant association between SCE and mortality in a multivariable analysis (Table 3, OR, 1.9, $P = .038$). Other covariates used to control confounding were also found to be significantly associated with mortality, including emergency cases (OR, 3, $P = .027$), weekend cases (OR, 2.9, $P = .049$), and preoperative predicted mortality.

TABLE 2. Multivariable logistic regression comparing predictors of sharp count error

Predictor	OR (95% CI)	*P* value
First start case	0.76 (0.62-0.93)	.006
Weekend case	1.6 (1.66-3.47)	<.001
No. of CNs		
2	2.02 (1.27-3.21)	.003
3	2.16 (1.35-3.44)	.001
4	3.74 (2.31-6.04)	0
5	5.27 (3.12-8.9)	0
No. of SPs		
2	1.18 (0.9-1.56)	.24
3	1.56 (1.14-2.14)	.005
4	2.22 (1.49-3.3)	<.001
5	3.16 (1.67-5.97)	<.001

OR, Odds ratio; *CI*, confidence interval; *CN*, circulating nurse; *SP*, scrub person.

Despite SCEs being present in 10% of cardiac operations, there were no sharps retained inside patients and not a single x-ray resulted in operative reexploration. The case mix is shown in Figure 4. Only specific cases eligible for STS database reporting are known. The remaining non-STS cases are grouped as "Other."

DISCUSSION

This study is the first of its kind to expose the impact of team turnover on care in the operating room. Hand-offs are known to lead to serious and costly clinical consequences throughout the hospital, because critical clinical information must be transferred between providers during these transitions.[3-5] In addition to gaps in communication during hand-offs, introducing new personnel during an operation who were not involved in the original preoperative huddle may be another factor that increases the risk of adverse events (Video 1).[6]

SCEs have been well studied, and the collective evidence suggests that sharps and miscellaneous items are commonly miscounted and have been retained in patients. Needles are the most likely surgical item to be miscounted, although needles are retained less often than they are miscounted. However, incorrect counts are a concerning risk factor for overall retained surgical instruments occurrence.[7,8] SCEs are ubiquitous, and there are many ways current inventory methods can fail.[9] Variable hand-off techniques for CNs and SPs can lead to misunderstanding and error in recording. Sharps can also be added to the surgical field and not documented. Very small needles are often used in cardiac surgery and can be lost in the surgical drapes. Surgeons must make a conscious effort to hand every needle back directly to the SP to avoid this type of error; however, high-acuity situations can lead to both the surgeon and the SP overlooking the sharp count, and if the SP is substituted during or soon after these situations, errors in sharp count are likely to happen. Other reasons for SCE include competing demands, loud music, and talking.[10]

To examine if there is an association of SCEs on patient outcomes, we looked at the effect of team turnover and SCEs on in-hospital mortality in our STS indexed case cohort. We found that patients who have an SCE during their operation have almost double the risk of mortality during their index hospitalization than cases with correct counts. SCEs clearly represent another surrogate marker of case complexity and translate to higher mortality. To control for measured potential confounders in the dataset, we

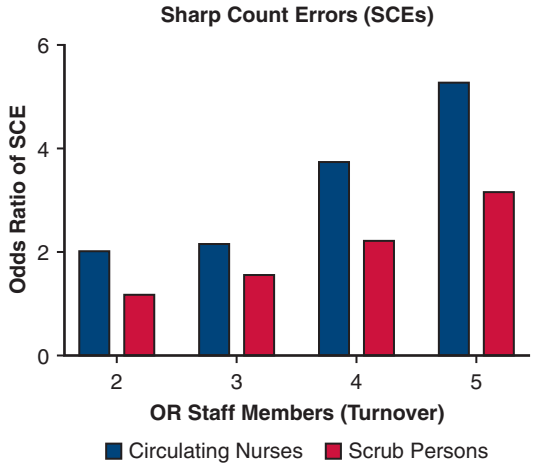

FIGURE 3. Likelihood of SCEs based on operating staff turnover. *SCE*, Sharp count error.

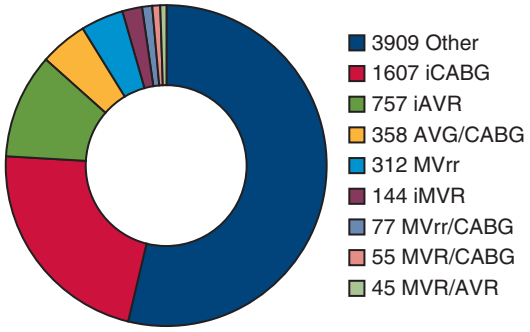

FIGURE 4. Operative case mix. "Other" cases are those not linked to institutional STS database. *iCABG*, Isolated coronary artery bypass grafting; *iAVR*, isolated aortic valve replacement; *AVR/CABG*, aortic valve replacement + coronary artery bypass grafting; *MVrr*, mitral valve repair; *iMVR*, isolated mitral valve replacement; *MVR/CABG*, mitral valve replacement + coronary artery bypass grafting; *MVR/AVR*, mitral valve replacement + aortic valve replacement.

included a number of known predictors of mortality in our multivariable analysis. The fact that an SCE remains a strongly significant predictor of mortality after adjustment further supports any effort to eliminate error in the operating room.

Although causality cannot be inferred between SCEs and patient mortality, SCEs do lead to increased hospital costs. In addition to the cost of the operating room, charges associated with obtaining extra imaging and paying the staff who remain in the operating room during this time are significant and could be avoided. A large study of operating room efficiency found that intraoperative radiography resulted in the longest delay and on average added 40 minutes of time to the case.[11] Because providers are required to remain in the operating room while the error is investigated, the delay can also lead to poor morale and a negative perception of those who were involved in the error. Finally, extra safety report incident documentation must be filed, which costs both time and money. In our large study with a high prevalence of SCEs, the mandatory investigatory x-ray(s) resulted in 1 operative reexploration.

Standardized preoperative communication practices, such as a briefing, huddle, and hard stop timeout that include a surgical checklist, have been shown to improve the quality of care and decrease error.[12] All team members are expected to be present for these communication practices before and at the start of the operation. Our data show a significant increase in the propensity for SCEs with increased team turnover during a single operation. A hostile interaction with a surgeon may influence operating room personnel to take more frequent breaks during their

TABLE 3. Multivariable analysis: Predictors of in-hospital mortality

Predictor	OR (95% CI)	*P* value
Emergency case	3.03 (1.14-8.08)	.027
First start case	0.89 (0.44-1.8)	.745
Weekend case	2.94 (1.01-8.59)	.049
No. of circulating RNs		
2	0.69 (0.19-2.48)	.584
3	0.69 (0.18-2.65)	.573
4	1.26 (0.29-5.43)	.594
5	0 (0-0)	.758
No. of SPs		
2	0.65 (0.32-1.3)	.221
3	0.9 (0.42-1.93)	.793
4	1.77 (0.72-4.39)	.217
5	0.87 (0.1-7.66)	.903
Predicted mortality (%)		
Moderate	18.7 (2.55-140.32)	.004
High	60.4 (9.18-495.49)	<.001
SCE	2.2 (1.09-4.36)	.028

OR, Odds ratio; *CI*, confidence interval; *RN*, Registered Nurse; *SP*, scrub person; *SCE*, sharp count error.

VIDEO 1. Dr Jordan Bloom (first author) interviewing Dr David D'Alessandro (cardiac surgeon and senior author) and Carolyn Burkhardt (clinical nurse manager for cardiac surgery and coauthor) about the findings of the study. Video available at: https://www.jtcvs.org/article/S0022-5223(19)34022-X/fulltext.

shift, and poor team dynamics can lead to more errors overall. Our study is limited in that it examines the effect of shift turnover on SCEs but did not include data on the number of breaks that were taken during each case. We assume that the large sample size of cases included in the study will account for the variability in operating room ''mood,'' surgeon behavior, and its influence on operating room turnover.

From the results of this study, a compelling argument can be made for minimizing turnover in the operating room altogether; however, we do acknowledge that the long and tedious nature of cardiac operations makes it necessary for staff to take breaks and transition care. The study raises awareness about a previously undervalued problem, and we encourage operating room administrators to evaluate potential pitfalls in workflow and identify practices that may have room for improvement. At our institution, we may consider switching from a paper-based recording system to electronic methods where all sharps are scanned. Individual surgeons may also use this information to improve practices when turnover occurs. If feasible, a surgeon may institute a brief time-out or recalibration during a long operation to give all new staff time to acclimate and ''catch up.'' Some institutions strictly mandate pauses or timeouts during counts.[10,13]

Study Limitations

Although this study illuminates an important challenge in the operating room, it is limited because of the retrospective design. First, there are many confounders and variables that we could not analyze given the lack of granularity of our database. Most first start cases are not emergency; therefore, the lower acuity nature of these cases may have contributed to lower errors rather than fewer turnovers. The dataset used for this study contained comprehensive information about sharps inventory and CN/SP turnover. Unfortunately, the dataset lacks clinical information about the patients or procedures; thus, we were unable to ascertain baseline patient demographics for each group in the study and cannot conclude that the groups were similar. This also made it difficult to build a robust multivariable model for appropriate adjustment. Case mix included a large number of unknown cases. This again was a limitation of the dataset, Finally, causation cannot be determined from retrospective research, but projects like this can never be studied using prospective methods to achieve the highest level of evidence.

CONCLUSIONS

More turnover in the operating room increases the propensity for error and further investigation on minimizing turnover, and optimizing hand-off practices for CNs and SPs should be undertaken. In addition, turnover for the other professionals in the operating room should be examined for potential deleterious effects on quality healthcare delivery.

Webcast

You can watch a Webcast of this AATS meeting presentation by going to: https://aats.blob.core.windows.net/media/18Apr30/Theater%201%20Booth%20134/S58_1_webcast_090635040-%20Operating%20Room.mp4.

Conflict of Interest Statement

Authors have nothing to disclose with regard to commercial support

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Key Words: operating room staff turnover, patient safety, sharps inventory, cardiac surgery