Healthcare improvement based on learning from adverse outcomes

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Chapter 4

Learning from morbidity and mortality conferences: focus and sustainability of lessons for patient care

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ABSTRACT

Objectives

It remains unclear to what extent the morbidity and mortality conference (M&M) meets the objective of improving quality and safety of patient care. It has been suggested that M&M may be too focused on individual performance, hampering system-level improvement. Aim of this study was to assess focus and sustainability of lessons for patient care that derive from M&M.

Methods

Observational study of routinely collected data on evaluated complications and identified lessons at surgical M&M over 8 years, assessing type and recurrence of lessons and cases from which these were drawn. Semi-structured interviews with clinicians were qualitatively analyzed to explore factors contributing to lesson focus and recurrence.

Results

318 lessons were drawn from 10,883 evaluated complications, primarily for those that were more severe, related to surgical or other treatment, and occurring in non-emergent, lower risk cases (all P<.001). Most lessons targeted intraoperative (43%) rather than pre- or postoperative care, and specifically technical (87%) and individual-level issues (74%). There were 43 recurring lessons (14%), mostly about postoperative care (47%) and medication management (50%). Interviewed clinicians attributed the intraoperative, technical focus primarily to greater appeal and control, but identified an array of factors contributing to lesson recurrence, such as typical staff turnover in teaching hospitals.

Conclusions

This study provided empirical evidence that learning at M&M has a tendency to focus on intraoperative, technical performance, with challenges to sustain lessons for more system-level issues. M&M formats need to anticipate these tendencies to ensure a wide focus for learning with lasting and wide impact.

Key words: morbidity and mortality conference; patient safety; quality improvement; continuing education.

INTRODUCTION

The morbidity and mortality conference (M&M) is healthcare's oldest forum for learning and improvement. Following its introduction in the early 20th century this traditional 'golden hour of the surgical workweek'[1] has been adopted by many specialties outside of surgery.[2–4] While many studies have assessed M&M practice,[5] literature is scarce on the extent to which M&M actually meets the objective of improving the quality and safety of patient care.

An inherent problem in M&M research is that it is unrealistic to use changes in clinical outcomes (e.g. complication rates) to assess M&M success, as the conference's impact cannot be isolated from other advancements in clinical practice. Instead, the number of lessons learned at M&M may serve as a first measure of success.[4,6] However, M&M lessons are often not routinely documented and empirical studies of lessons are unavailable.[7,8] Despite this lack of evidence, there are indications M&M is too focused on individual performance rather than systems issues.[5,9–15] Such a narrow focus would be unsuccessful, as it has been widely acknowledged that addressing system-level factors is paramount to achieve sustainable improvements.[6,11,16]

This study assessed lessons learned at M&M of a surgical department with a robust and standardized process for reporting and evaluation of complications, including routine documentation of all lessons learned. Lessons were analyzed for frequency, type, related patient cases, and recurrence of similar lessons over time. In addition, surgical faculty and residents were interviewed to reflect on observations to gain more insight in factors contributing to the focus and recurrence of lessons. We hypothesized that the most frequent type of lessons would provide insight into the focus of learning at M&M, and that recurrence of lessons would reveal where it is more difficult to realize and sustain improvements.

METHODS

This observational study analyzed all routinely reported and evaluated complications, referred to as adverse events (AEs), of all surgical inpatients discharged from Leiden University Medical Center (LUMC) between January 2003 and April 2011. This time frame was selected because data collection, part of routine practice, was known to be very consistent and robust in that period, ensuring reliable data over various years. The LUMC is an 882-bed Dutch university hospital, in which the surgical department has an annual inpatient volume of approximately 3400 patients, covering general, endocrine, vascular, gastrointestinal, pediatric, oncologic, trauma and transplant surgery. In the Netherlands, an adverse event is defined as *any unintended or unwanted event or state occurring during or following medical care that requires adjustment of treatment or results in permanent damage.*[17] This definition excludes interpretation of causality from reporting, as it includes AEs related to underlying disease or comorbidities.

For institutions using the WHO definition that an AE is *an injury related to medical management, in contrast to complications of disease,*[18] this is referred to as a 'hospitalization-related AE' in the present study.

Reporting and evaluation process

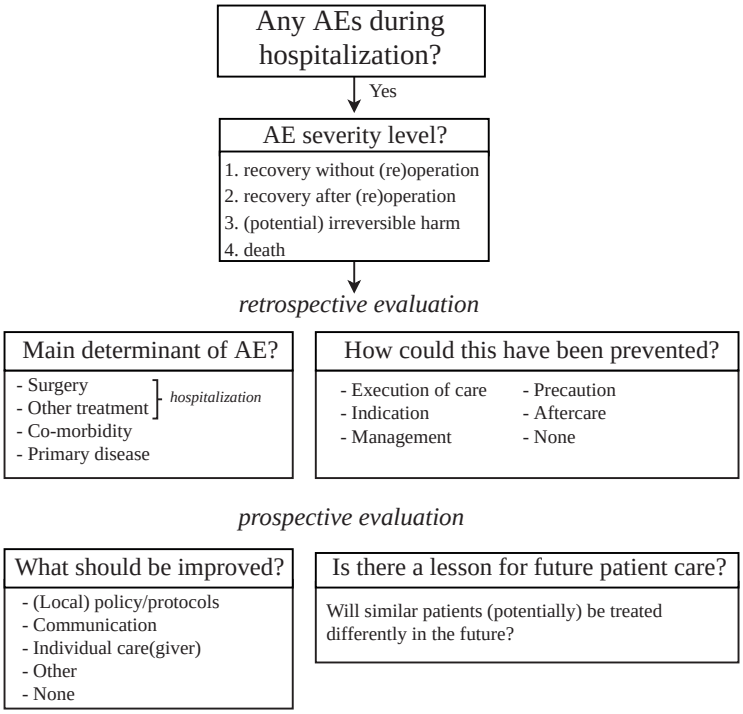
The process for routine AE reporting, implemented in 1997, has been described in prior publications, including its effectiveness being similar to record review.[17,19] Surgeons reported all AEs prospectively during admission or at patient discharge, and assigned severity levels reflecting consequences for the patient (Figure 1). AEs leading to reoperation, irreversible harm or death (i.e. severity level ≥2) or those with ≥3 AEs within an admission, were automatically selected for collective evaluation at M&M. Other AEs were individually evaluated by surgeons, who actively added an AE to M&M if they anticipated it would give rise to a lesson for patient care. The weekly M&M conference was mandatory for all surgical faculty, residents, physician assistants and medical students, and lasted about 1 hour. Cases were presented by residents responsible for the ward at time of patient discharge. The discussion was supported by literature reviewed by presenters and expert advice from the audience. All AE evaluations (collectively at M&M or individually by surgeons) followed a fixed format. First, the main determinant and preventability of the AE were determined in hindsight, then the forward-looking question was raised whether similar cases in the future should be treated differently to prevent this type of AE. If yes, this was documented as a 'lesson learned at M&M' along with any actions that arose (including categories for improvement, e.g. protocol change) (Figure 1).

Statistical analyses

For all AEs, admission data on patient age, gender, length of stay, American Society of Anesthesiologists (ASA) physical status and emergent or elective status at the first surgical procedure were included. Lessons were categorized based on which phase of care was targeted for improvement using categories used in a prior publication (Table 1).[21] Lessons regarding non-interventional care were categorized as postoperative. Discharge dates were used as dates of lessons. Recurring lessons were defined as *all lessons targeting a clinical issue similar to one or more preceding lesson(s)*, and were identified using manual text searches with sub-selections on phase of care and keywords for clinical topics.

AEs with and without lessons were compared using χ^2 tests and Fisher's exact test if expected count was less than five for categorical variables, and *t*-tests for continuous variables except length of stay (Mann-Whitney U test). All AEs had the potential to give rise to a lesson, either via automatic selection or manual submission to M&M, but there was no record of which cases had been manually added. Therefore, two estimates of AEs evaluated at M&M were obtained for analyses: an upper-bound estimate that included all reported AEs (main analysis), and a lower-bound estimate that included all AEs meeting criteria for automatic selection as well

Figure 1. Process of reporting and evaluation of adverse events.



Group evaluation at M&M of AEs in case of ≥3 AEs during admission, AEs severity ≥ 2 or if requested by reporting physicians. Other cases are evaluated by treating physicians during AE reporting according to the same format. 'Individual care(giver)' refers to improvements related to the care provided by the individual provider(s) in the specific case, such as improving individual technical skills or protocol adherence (e.g. 'amputation should have been performed sooner in this case').

as other AEs for which M&M lessons had been recorded (supplemental analysis). Statistical analyses were conducted using SPSS Statistics (IBM, v23) with a 0.05 alpha level.

To reflect on factors contributing to type and recurrence of lessons observed in this study, semi-structured interviews were conducted with 6 attending surgeons, 5 surgical residents in training, and 1 physician assistant (PA) (median local work experience: 5 years [1-18 years]). Participants were selected using purposive, heterogeneous sampling - varying gender, seniority and subspecialty - to obtain a diversity of viewpoints. Interviews were audio-taped, transcribed verbatim and analyzed with inductive, data-driven, thematic content analysis using qualitative analysis software (Atlas.ti, GmbH, v7).[22] Coding was performed by the interviewer (MdV), re-assessed by a research assistant and discussed until consensus was reached.

Table 1. Phases of care and subcategories used to categorize lessons that derived from M&M.

Phase of care	**Subcategories** *(example)*
Preoperative care	Indication *(time-to-surgery)*
	Workup *(imaging)*
	Medication *(antibiotic prophylaxis)*
	Communication *(planning the surgery)*
Intraoperative care	Technical aspects of surgery *(suturing)*
	OR circumstances *(instrument counting)*
	Operative medication *(blood transfusion in OR)*
Postoperative care	Postoperative management *(fluid management)*
	Medication *(heparin dosing)*
	Central venous catheters, urinary catheters and tubes *(nasogastric tube)*
	Physical care *(pressure ulcer prevention)*
	Communication *(medical record keeping)*

OR, operating room.

RESULTS

A total of 10,883 AEs were reported and evaluated in the study period, occurring in 5259 of all 28,539 (18.4%) inpatient admissions (Table 2). The most commonly selected main determinant for AEs was (surgical) treatment (i.e. hospitalization) (77.6% of 10,883), rather than primary disease (12.6%) or comorbidities (9.8%). A total of 318 AEs (2.9%) resulted in lessons learned, most of which were AEs considered preventable (98.7%) (Table 2). Among all 1626 AEs considered preventable (i.e. 15.0% of all AEs; 18.6% of hospitalization-related AEs), approximately 1 out of 5 resulted in a lesson (19.3% of 1626). Of the 4487 AEs related to surgery, 189 (4.2%) had lessons, and 4298 (95.8%) did not have lessons.

Cases from which lessons were drawn

AEs that gave rise to lessons had similar patient characteristics compared to AEs without lessons, except for lessons occurring more often in patients with lower ASA status and elective status (Table 2). Lessons were more often identified for more severe AEs, related to hospitalization, and specifically surgery (all P<.001).

At least 7106 AEs (65.3% of 10,883), occurring in 2336 inpatient cases, will have been collectively evaluated at M&M as they met selection criteria (i.e. ≥3 AEs or AE severity ≥2, n=7018) or had recorded lessons (n=88). In this subset, lessons were recorded for 4.5% of all AEs and 24.2% of all preventable AEs and differences regarding patient characteristics were similar, with the exception of significantly lower length of stay for AEs with lessons (Appendix 1).

Table 2. Differences between AEs that resulted in lessons and AEs without lessons.*

Variable	All AEs reported (N=10,883)		AEs with lessons n=318 (2.9)		AEs without lessons n=10,565		P
Age, years	60.3 ± 17.4		59.3 ± 18.7		60.3 ± 17.4		0.336
Male gender	6343	(58.3)	192	(60.4)	6151	(58.2)	0.422
Length of stay, days	29.7 ± 37.2		26.4 ± 35.8		29.8 ± 37.2		0.355
Underwent surgery	9753	(89.6)	292	(91.8)	9461	(89.6)	0.190
Status at first surgery†							
elective	6185	(63.4)	212	(72.6)	5973	(63.1)	0.004*
emergency	921	(9.4)	20	(6.8)	901	(9.5)	
missing	2647	(27.1)	60	(20.5)	2587	(27.3)	
ASA at first surgery†							
I	579	(5.9)	38	(13.0)	541	(5.7)	<0.001*
II	2773	(28.4)	96	(32.9)	2677	(28.3)	
III	2771	(28.4)	79	(27.1)	2692	(28.5)	
IV	732	(7.5)	11	(3.8)	721	(7.6)	
V	241	(2.5)	8	(2.7)	233	(2.5)	
missing	2657	(27.2)	60	(20.5)	2597	(27.4)	
Severity level							
1) recovery without operation	8284	(76.1)	162	(50.9)	8122	(76.9)	<0.001*
2) recovery with operation	1797	(16.5)	113	(35.5)	1684	(15.9)	
3) (potential) irreversible harm	316	(2.9)	29	(9.1)	287	(2.7)	
4) death	475	(4.4)	11	(3.5)	464	(4.4)	
undetermined	11	(0.1)	3	(0.9)	8	(0.1)	
Main determinant							
Surgery‡	4487	(41.2)	189	(59.4)	4298	(40.7)	<0.001*
Other than surgery	6389	(58.7)	129	(40.6)	6260	(59.3)	
Hospitalization‡	8439	(77.6)	295	(92.8)	8144	(77.1)	<0.001*
Other than hospitalization	2437	(22.4)	23	(7.2)	2414	(22.9)	
Preventability§							
Preventable	1626	(15.0)	314	(98.7)	1312	(12.5)	<0.001*
Not preventable	9207	(85.0)	4	(1.3)	9203	(87.5)	
By execution of care	1061	(9.8)	151	(47.5)	910	(8.7)	<0.001*
Not by execution	9772	(90.2)	167	(52.5)	9605	(91.3)	
Improvement‖							
Individual care(giver)	621	(5.7)	233	(73.7)	388	(3.7)	<0.001*
Non-individual	10,252	(94.3)	83	(26.3)	10,169	(96.3)	

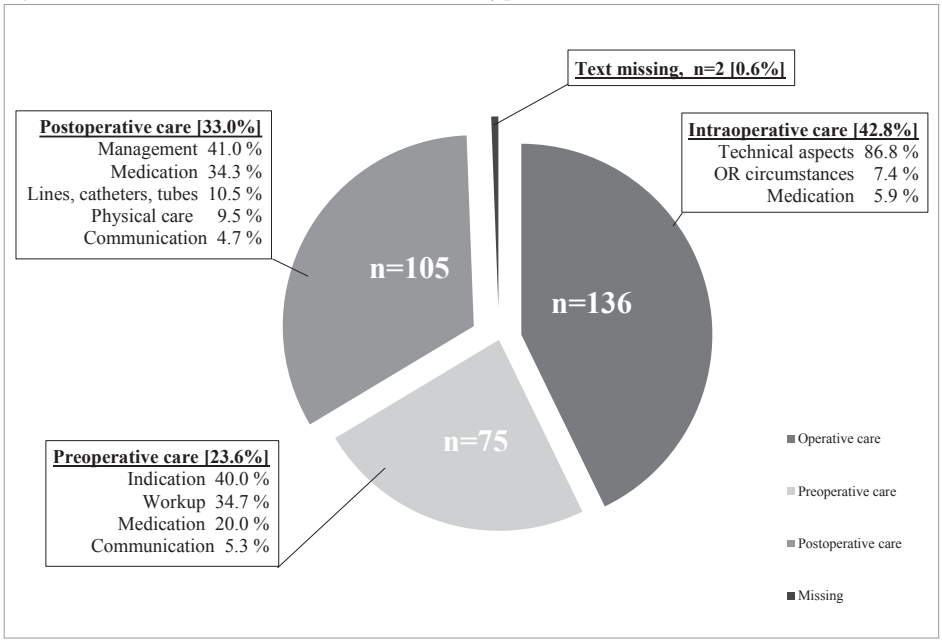
AEs, adverse events. *ASA*, American Society of Anesthesiologists physical status. Categorical data presented as number (column %, excl. missing), continuous data as mean ± standard deviation. * corresponds to P-value significant at the 0.05 level. † ASA and (non)-emergent status are recorded at first surgical procedure during admission, therefore these numbers are presented as % of all patients who underwent surgery (total reported AEs, n=9753; AEs with lessons, n=292; AEs without lessons n=9461). ‡ Surgery: main determinant surgery, rather than other treatment, comorbidity or primary disease. Hospitalization: main determinant surgery or other treatment, rather than comorbidity or primary disease. Missing for 7 AEs. § Missing for 50 AEs. || Missing for 10 AEs.

Type and recurrence of lessons

Most lessons concerned intraoperative care (n=136, 42.8%) and primarily technical aspects of surgery (86.8% of 136) rather than circumstances (7.4%) or medications (5.9%) in the operating room (Figure 2). Among lessons, 'individual care(giver)' (i.e. related to the specific case and provider(s), e.g. 'amputation should have been performed sooner in this case') was nearly three times more frequently selected (73.7%) than more system-level categories for improvement, such as 'communication' and 'protocols'. (Table 2). Among the 475 deceased patients, 11 AEs (2.3%) resulted in lessons, of which 8 (72.7%) were related to individual-level improvements.

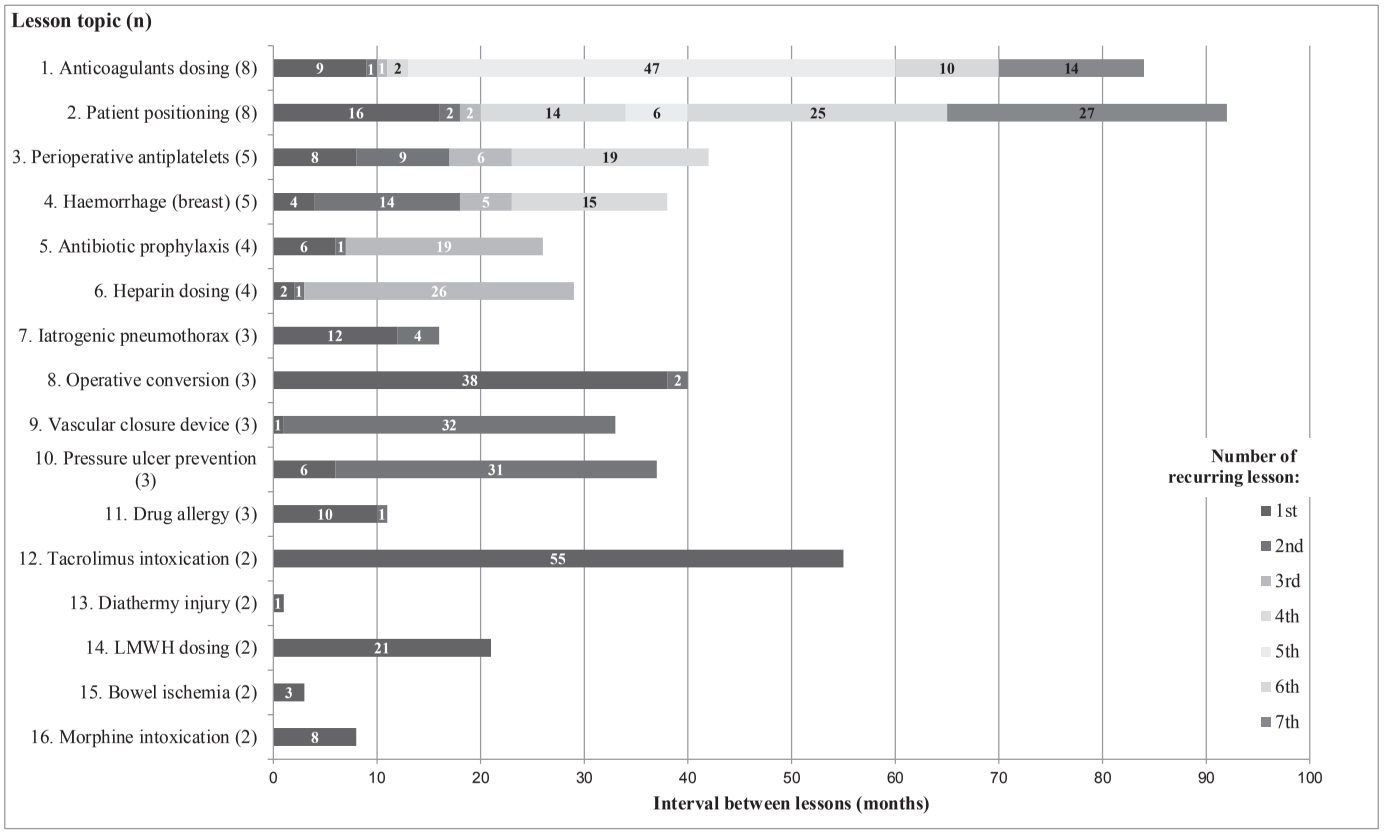
A total of 43 lessons (13.5% of 318) were recurring lessons following 16 similar lessons documented earlier in time (Figure 3). Most of these 43 recurring lessons concerned postoperative care (46.5%) (preoperative 9.3%; intraoperative 44.2%) (Appendix 2). Among recurring lesson topics, most concerned medication (50.0% of 16) (e.g. anticoagulants, morphine), followed by operative topics (37.5%) (e.g. patient positioning, intraoperative conversion from laparoscopic to open cholecystectomy) (Figure 3). Most recurring lessons were recorded in the first half of the study period (26 of 43 recurrences, 60.5%). To illustrate, recurring lessons on anticoagulants mostly derived from hemorrhagic AEs and called for improvements in International Normalized Ratio (INR) monitoring or associated protocols. On average, recurring lessons had a frequency of 2 per year with time intervals ranging widely (1-55 months).

Figure 2. All lessons that derived from M&M, stratified by phase of care (n=318).



OR, operating room.

Figure 3. Recurring lessons per topic with intervals (months) between subsequent lessons.



LMWH, low-molecular-weight heparin. Recurrence of similar lessons (initial lesson=0 on *x*-axis) with interval in months shown on each bar and total number of lessons at the end of bars (*n*). Intervals <1 month are displayed as '1'.

Most recurring lessons were identified for 'anticoagulant dosing' (8 in 7.3 years), 'patient positioning' (8 in 8.0 years) and 'perioperative antiplatelet therapy' (5 in 3.7 years) (Figure 3).

Contributing factors perceived by clinicians

Nearly all interviewed attendings and residents (11/12) attributed the predominance of intraoperative lessons to these being more appealing and more within a surgeon's control.

> *"I can do whatever but if they [anesthesiologists] don't order the next patient, then they just don't, so I cannot control that. While if another type of surgical thread will improve my results, then I'll change this myself." (#9)*

Recurrence of postoperative lessons was similarly attributed to lower appeal and less control for issues outside the operating room. However, 10 other factors were perceived to contribute to recurrence of lessons, such as sense of urgency and complexity. Appendix 3 presents all factors with illustrative quotes. Complexity of (sustaining) lessons was believed to increase with the number of people involved thus being harder for multidisciplinary care. Most frequently mentioned were 'typical staff turnover in teaching hospitals' and 'lack of protocol clarity/adjustments.'

> "*Well definitely the high turnover of staff [plays a role]. Not faculty but the team of residents changes every half year. People leave and new people arrive." (#12)*

'Staff turnover', 'multidisciplinary involvement' or 'control' were mostly mentioned by attendings (6 of 6 attendings vs. 3 of 6 residents/PA), while 'greater appeal' or 'protocol issues' were mostly reported by residents (2 of 6 attendings vs. 6 of 6 residents/PA) as factors contributing to lesson recurrence.

DISCUSSION

This study assessed lessons deriving from M&M over 8 years, and demonstrated what was learned, not learned and more difficult to learn through M&M. Lessons were recorded for 3% of all AEs and 19% of all AEs that clinicians deemed preventable. AEs that were more severe, related to (surgical) treatment, or occurring in non-emergent and lower risk cases, more commonly gave rise to lessons. While most lessons concerned intraoperative and technical performance, lessons that recurred over time mostly concerned postoperative care and medication management. Interviewed clinicians attributed this intraoperative, technical focus mainly to greater appeal and control for surgeons, but recurrence of lessons was attributed to an array of

factors, of which mostly mentioned were typical staff turnover in teaching hospitals and lack of protocol clarity or adjustments.

Individual focus

This study provided empirical evidence that lessons learned at M&M focused on individual and technical performance, even though the used format tried to also include system-level factors. These findings support prior indications that M&M may be too focused on the individual rather than the system level.[5,9–11,13-15] Individual responsibility is deeply embedded in surgical culture and improving technical skills is laudable and important.[23] However, achieving (sustainable) improvement frequently requires addressing more distant, system-related factors,[16,24,25] as also addressed in the ACGME core competency 'systems-based practice'.[26–29] A focus on individuals rather than the system, also increases the risk of blame, a widely acknowledged barrier to learning since landmark works such as Bosk's field study of surgical training,[23] Wachter's book on medical error,[30] and the Institute of Medicine's reports.[31,32]

While it has been shown that just as many determinants of complications can be identified in the pre- and postoperative as intraoperative phase of care,[7] most lessons learned at M&M appeared to target intraoperative issues in this study. Moreover, fewer lessons were drawn from higher risk cases and less severe AEs. This could be related to the fact that AEs may be considered more likely to occur in these higher risk cases, and hence more likely attributed to patient factors rather than considered a lesson for the future. This is in line with studies describing how feelings of ownership and control may affect reporting cases to M&M: cases with primarily 'medical' problems, incurable disease or less severe AEs tended not to be reported.[11,33] This study adds that these factors also affect the subsequent process of learning at M&M, even in a setting where many cases are automatically selected for the conference.

Preventability

Many AEs considered preventable did not result in lessons, which likely reflects how not all events considered preventable in hindsight also have implications for the care clinicians would provide to similar patients in the future. After all, preventability can be easily judged in the comfort of hindsight, but anticipating care for future patients (i.e. lessons) involves weighing all potential future risks and benefits while also considering clinical dilemmas and trade-offs involved. This quandary is reflected in the debate on AE preventability in the literature, where estimates range widely (18-62%).[34–37] This study adds to this debate, as it presents preventability rates judged by clinicians themselves (15% overall and 19% of hospitalization-related AE), which are lower than those of studies using external reviewers that lack context knowledge and strongly depend on accuracy and completeness of medical records.[35,38,39] This study's rate of 381 AEs per 1000 hospitalizations (i.e. 10,883 AEs in 28,539 patients) is close to that recently reported for surgical patients (368 per 1000).[40]

Recurring lessons

Recurring lessons can reveal areas with repetitive problems and stimulate increased attention to these matters. Overall, most lessons concerned intraoperative individual performance, but recurring lessons primarily addressed issues outside the operating room and/or involving multiple disciplines (e.g. medication management, patient positioning). Interviewed clinicians stressed that it can be particularly challenging to sustain improvements for activities mainly carried out by rotating residents with additional involvement of other disciplines. In theory, protocols can serve as a vehicle to propagate these lessons, but in actual practice, protocols may often be unclear or not updated, as also noted in interviews. The recurring lessons on perioperative antiplatelet therapy (i.e. aspirin cessation) and hemorrhage after breast surgery illustrate how particularly lessons that change local policies may trigger more recurring lessons. Protocols were changed but appeared to be incomplete or not adhered to in practice, which resulted in more lessons (Appendix 2).

That recurrence of lessons was less common in the later years of this study might indicate success of M&M. However, it may also be explained by the fact that these lessons had more time to have a recurrence than lessons in the last part of the study period. Moreover, there may be other reasons why lessons do not recur, for instance because the opportunity for learning is missed. Similarly, it is difficult to attribute changes in clinical outcomes to M&M success, as complications have various underlying causes and clinical practice is subjected to many other changes and improvements simultaneous to M&M. Instead 'recurring lessons' might be a better parameter to assess where M&M is less successful, revealing areas where prior lessons learned may not have been effective enough and require more attention.

Practical implications

A robust registry of lessons can be used to monitor the type of lessons learned at M&M and those recurring over time, as illustrated by this study. M&Ms with systematic documentation of plans for improvement have been shown to have greater effectiveness, in terms of number of (completed) improvement initiatives.[4] To ensure a realistic and systems approach to learning, M&M practices should be adapted to anticipate the observed tendency to focus on individual, intraoperative performance. Rather than reviewing single cases, discussing similar cases together, along with local and international data[41] on complications or other outcomes (e.g. incidents, complaints), may emphasize a system perspective and increase sense of urgency. Furthermore, this could occur at the subspecialty or ward level rather than department level**,** as staff may be more committed to 'their own' AEs (ownership) as well as more acquainted with, and more empowered to change (control), processes related to their own subspecialty. Issues relevant for all subspecialties can still be discussed at departmental conferences. Finally, greater multidisciplinary participation (i.e. medical specialists, nursing and paramedical staff) may widen the conference's focus beyond intraoperative care and increase the ability to achieve and sustain improvements, which requires early involvement of all who provide care.[42]

While multidisciplinary M&M would require substantial organizational efforts, this is recommended by recent M&M studies,[5,43,44] demonstrating positive effects on available information and teamwork.[9,26,27,45]

Strength and limitations

A strength of this study is that it reviewed a large number of complications routinely evaluated by surgeons along with the systematically collected lessons learned at M&M over 8 years. A limitation of this study is its inability to assess whether recorded lessons were adequate enough, completed or effective, hence it remains unclear whether non-recurring lessons were successful. While evaluations of complications are always affected by 'eye of the reviewer',[39] the fact that these largely took place in group discussions aided by fixed formats will likely have decreased inter-observer bias. Conceptions of quality and preventability may differ and alter over time, which needs to be taken into account when interpreting this study's estimates for preventability.[46] However, the generic mechanisms by which we learn from M&M are less likely to have changed in recent years. Therefore, we believe that the used data from 2003-2011, selected for consistency and reliability, are still timely and relevant. An important study limitation is that it remains unclear to what extent findings translate to other settings, particularly non-teaching hospitals. Nonetheless, while conducted at a single academic center, recurring lessons highlighted typical bottlenecks for surgical and inpatient care, reported to pose safety risks, such as medication management, specifically of anticoagulants.[35,40,47–50] Moreover, this study supports prior suggestions, made in other settings, that M&M may be too focused on individual and technical skills.[5,9–13] While M&M formats may differ between institutions, expectations and challenges for M&M practices are likely more similar,[51] which makes these findings relevant to others committed to learn through M&M and subsequently sustain lessons for patient care.

CONCLUSIONS

Lessons that derived from surgical M&M conferences over 8 years were mostly drawn from lower risk cases, more severe or surgery-related AEs, and primarily targeted individual intraoperative performance. Lessons recurring over time particularly concerned postoperative and medication management involving multiple disciplines. Future studies should test possible interventions to ensure a wide focus for learning at M&M and sustaining of lessons learned.

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Appendix 1. Sub analysis: differences between AEs with and without resulting lessons among a subset of AEs that have been evaluated at M&M (i.e. all AEs meeting automatic selection criteria and other AEs with recorded lessons).

Variable[1]	*AEs evaluated at M&M* n=7106[2]		*AEs with lessons* n=318 (4.5)		*AEs without lessons* n=6788		*P*
Age, years	60.7± 17.0		59.3 ± 18.7		60.7 ± 16.9		0.193_
Male gender	4279	(60.2)	192	(60.4)	4087	(60.2)	0.952_
Length of stay, days	39.0 ± 42.2		26.4 ± 35.8		39.7 ± 42.3		<0.001*
Underwent surgery	6552	(92.2)	292	(91.8)	6260	(92.2)	0.796_
Status at first surgery[3]							
elective	4001	(61.1)	212	(72.6)	3789	(60.5)	<0.001*
emergency	622	(9.5)	20	(6.8)	602	(9.6)	
missing	1929	(29.4)	60	(20.5)	1869	(29.9)	
ASA classification[3]							
I	261	(4.0)	38	(13.0)	223	(3.6)	<0.001*
II	1581	(24.1)	96	(32.9)	1485	(23.7)	
III	1916	(29.2)	79	(27.1)	1837	(29.3)	
IV	644	(9.8)	11	(3.8)	633	(10.1)	
V	215	(3.3)	8	(2.7)	207	(3.3)	
missing	1935	(29.5)	60	(20.5)	1875	(30.0)	
Severity level							
1) recovery without operation	4507	(63.4)	162	(50.9)	4345	(64.0)	<0.001*
2) recovery with operation	1797	(25.3)	113	(35.5)	1684	(24.8)	
3) (potential) irreversible harm	316	(4.4)	29	(9.1)	287	(4.2)	
4) death	475	(6.7)	11	(3.5)	464	(6.8)	
undetermined	11	(0.2)	3	(0.9)	8	(0.1)	
Main determinant[4]							
Surgery	2960	(41.7)	189	(59.4)	2771	(40.9)	<0.001*
Other than surgery	4139	(58.3)	129	(40.6)	4010	(59.1)	
Hospitalization	5268	(74.2)	295	(92.8)	4973	(73.3)	<0.001*
Other than hospitalization	1831	(28.8)	23	(7.2)	1808	(26.7)	
Preventable	1299	(18.4)	314	(98.7)	985	(14.6)	<0.001*
Not preventable	5763	(81.6)	4	(1.3)	5759	(85.4)	
By execution of care	6218	(88.0)	151	(47.5)	693	(10.3)	<0.001*
Not by execution	844	(12.0)	167	(52.5)	6051	(89.7)	
Improvement[6]							
Individual care(giver)	539	(7.6)	233	(73.7)	306	(4.5)	<0.001*
Non-individual	6557	(92.4)	83	(26.3)	6474	(95.5)	

Categorical data presented as number (column %, excl. missing) and continuous data as mean ± standard error. * corresponds to P-value significant at the 0.05 level. [2] These 7106 AEs were reported for a total of 2336 inpatient admissions. [3] These variables represent ASA and (non)-emergent status recorded at first surgical procedure during admission, therefore these numbers are presented as % of patients who underwent surgery (AEs evaluated at M&M, n=6552; AEs with lessons, n=292; AEs without lessons, n=6260). [4] Surgery: main determinant surgery, rather than other treatment, comorbidity or primary disease. Hospitalization: main determinant surgery or other treatment, rather than comorbidity or primary disease. Missing for 7 AEs. [5] Missing for 44 AEs. [6] Missing for 10 AEs.

Appendix 2. Recurring lessons with dates and related adverse events.

Shared topic of recurring lessons (n)	Date	Lesson content (phase: preoperative (I), intraoperative (II) or postoperative (III))[1]	Related adverse event
1. Anticoagulants dosing (8)	06/2003	Lack of protocol for perioperative management of patients with ulcers, antacids and anticoagulants. (I)	Hemorrhagic shock
	04/2004	Do not just continue dosing. Protocols need adjustment to meet patient subgroups' needs (elderly). (III)	INR elevation
	06/2004	INR monitoring was too short. (III)	Hemorrhage with INR elevation
	08/2004	INR lab results from weekend were not communicated, was measured without order but elevated! (III)	Hemorrhage with INR elevation
	11/2007	Anticoagulants dosing according to the newest protocol as explained by internal physician. (III)	Arterial bypass re-occlusion
	08/2008	Better monitoring of INR after cessation of anticoagulant therapy. (III)	Subcutaneous hemorrhage
	07/2009	Inquire which dose patients normally take at home. (III)	INR elevation
	09/2010	In case of treatment with split skin graft (SSG), stop anticoagulant therapy. (III)	Hemorrhage foot
2. Patient positioning (8)	03/2003	Improve positioning on operating table (prone position and leg rests). (II)	Occluded vascular prosthesis leg
	07/2004	Improve patient positioning for long surgeries.(II)	Peroneal neuropathy
	10/2004	Proper patient positioning. (II)	Peroneal neuropathy
	01/2005	Improve positioning on operating table or Intensive Care Unit (ICU) bed. (II)	Peroneal neuropathy
	03/2006	Pay attention to position of extremities in every intervention or ICU stay. (II)	Ulnar neuropathy
	10/2006	Properly place arm on arm rest. (II)	Ulnar neuropathy
	11/2008	Too much peroneal neuropathy in compartment syndrome case. (II)	Peroneal neuropathy
	03/2011	Beware of too much abduction or too high elevation of arms in anesthetized patients.(II)	Brachial plexus paresis
3. Perioperative antiplatelet policy (5)	02/2003	Antiplatelet therapy should be discontinued at an earlier stage prior to surgery. (I)	Postponed surgery
	11/2003	I(nter)national literature supports continuation of antiplatelet therapy because of stroke risk. (I)	Stroke
	08/2004	More precise, thorough hemostasis should be obtained in surgeries under antiplatelet therapy. (II)	Intraoperative hemorrhage
	03/2005	Suboptimal management: anesthesia has wrongfully discontinued antiplatelet therapy. (I)	Stroke
	11/2006	Again, antiplatelet therapy was wrongfully discontinued. This needs further exploration. (I)	Postoperative hemorrhage breast
4. Hemorrhage (breast surgery) (5)	04/2005	Department's policy/protocol has changed: postoperative drainage. (III)	Postoperative hemorrhage breast
	08/2005	Non-adherence to protocol. Refer to our hospital's protocol database. (III)	Postoperative hemorrhage breast after heparin administration
	11/2006	Again, antiplatelet therapy was wrongfully discontinued. This needs further exploration. (I)	Postoperative hemorrhage breast
	04/2007	Many hemorrhage problems in tissue expanders, sub pectoral preparation otherwise. (II)	Postoperative hemorrhage breast
	07/2008	Increase focus on hemostasis after surgery. (II)	Postoperative hemorrhage breast
5. Antibiotic therapy (4)	03/2005	What are the criteria for antibiotics in case of suspected wound infection? (III)	Wound infection leg/hip
	09/2005	Are there more undiagnosed wound infections due to a more aggressive antibiotic policy (e.g., more wound infections in cases with osteosynthesis material but less osteomyelitis?) (III)	Wound infection leg/hip
	09/2005	More aggressive antibiotic policy, 'preventative therapy'? (III)	Wound infection foot
	05/2007	Reconsider antibiotic prophylaxis, convert to prolonged antibiotic therapy (e.g., five days). (III)	Recurrent sub hepatic abscess

Appendix 2. Recurring lessons with dates and related adverse events. (continued)

Shared topic of recurring lessons (n)	Date	Lesson content (phase: preoperative (I), intraoperative (II) or postoperative (III))[1]	Related adverse event
6. Heparin dosing (4)	03/2003	Inadequate dosing of heparin. (III)	Postoperative hemorrhage
	05/2003	Inadequate dosing of heparin. (II)	Infected hematoma transplant
	06/2003	Improve heparin dosing. (III)	Catheter-induced hemorrhage
	08/2005	Non-adherence to protocol. Refer to our hospital's protocol database. (III)	Postoperative hemorrhage breast after heparin administration
7. Iatrogenic pneumothorax (3)	10/2004	Reassess protocols on pneumothorax after central line placement (drainage or not) (III)	Catheter-induced pneumothorax
	11/2005	Ultrasound-guided central line placement. (II)	Catheter-induced pneumothorax
	03/2006	Line placement in recovery room was not ultrasound-guided. (II)	Catheter-induced pneumothorax
8. Operative conversion (3)	12/2003	When in doubt about anatomy, always convert to open surgery, especially in case of infiltrate. (II)	Bile duct injury (laparoscopy)
	03/2007	In laborious procedures, timely conversion to open surgery. (II)	Bile duct injury (laparoscopy)
	06/2007	Convert sooner or call for assistance. (II)	Bile duct injury (laparoscopy)
9. Vascular closure device use (3)	09/2005	Be aware of complications of angioseal. (II)	Arterial occlusion angioseal
	10/2005	A lot of patency loss due to angioseal 5/150. Ultrasound check of patency? Local calcifications? (II)	Arterial occlusion angioseal
	06/2008	Do not use angioseal in superficial femoral artery. (II)	Arterial occlusion angioseal
10. Pressure ulcer prevention (3)	01/2004	Pressure ulcer prevention. (III)	Pressure ulcer heels
	07/2004	Pressure ulcer prevention? (III)	Pressure ulcer heels
	03/2007	Pressure ulcer prevention was insufficient. (III)	Pressure ulcer heels
11. Drug allergy (3)	09/2004	Received nitrofurantoin despite known allergy. (III)	Allergic reaction to antibiotics
	07/2005	How do we deal with allergies? (III)	Allergic reaction contrast agent
	08/2005	Read health records thoroughly. (III)	Allergic reaction contrast agent
12. Tacrolimus intoxication (2)	03/2004	Intravenously. (III)	Tacrolimus intoxication
	10/2008	Tacrolimus administration orally instead of intravenously. (III)	Tacrolimus-induced nerve injury
13. Diathermy injury (2)	01/2003	Do not put away the diathermy instrument on the patient's skin. (II)	Contact burn (diathermy)
	02/2003	Diathermy was placed on the patient's unprotected skin. (II)	Contact burn (diathermy)
14. LMWH dosing (2)	07/2008	Given body weight and pregnancy, a double dose of fraxiparin was indicated. (III)	Deep venous thrombosis (leg)
	05/2010	Double dose of fraxiparin is indicated for all pelvic fractures. Moreover, patient > 90 kilograms. (III)	Pulmonary embolism
15. Bowel ischemia (2)	01/2010	When anastomosis is in venous trajectory, first use heparin (IV) as thrombosis prophylaxis. (II)	Small bowel thrombosis
	05/2010	This lesson has been formulated recently! (II)	Small bowel ischemia
16. Morphine intoxication (2)	04/2004	In case of pin-point pupils: no analgesia, no full dose opiates (IM, subQ). (III)	Morphine intoxication
	01/2005	What is the relation between age and morphine intoxication? (III)	Morphine intoxication

[1] Lessons translated from Dutch to English. This table depicts 43 recurring lessons and the 16 initial lessons that preceded these. Phases of care among the 43 recurring lessons: preoperative (n=4, 9.3%), intraoperative (n=19, 44.2%), postoperative (incl. non-interventional care) (n=20, 46.5%).