

The Experience of Conducting Mortality and Morbidity Reviews in a Pediatric Interventional Radiology Service: A Retrospective Study

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PURPOSE: To review the experience and impact of conducting multidisciplinary Morbidity and Mortality (M&M) reviews in pediatric interventional radiology (IR) and describe issues, lessons, and recommendations.

MATERIALS AND METHODS: A dedicated functionality of an existing database was developed to retrospectively analyze pediatric IR M&M issues. Patient demographics, sedation/anesthesia, and procedure type were recorded. M&M issues were assigned to at least one of 10 categories and graded as major or minor per Society of Interventional Radiology (SIR) guidelines. Issues could result in recommendations, which were divided into six categories; each was classified as implemented or not implemented.

RESULTS: Of 31,983 patient encounters over a period of 10 years, 516 patient events (1.6%) were discussed at M&M reviews. A total of 772 categories were assigned; they related to the procedure (34%), patient comorbidity (20%), processes (15%), device (10%), management (8%), sedation/anesthesia (4%), medication (2%), ethical issues (1%), "near-misses" (1%), and other (5%). A total of 292 issues (57%) were graded as minor (SIR class A, $n = 202$; class B, $n = 90$) and 224 (43%) as major (SIR class C, $n = 42$; class D, $n = 151$; class E, $n = 6$; class F, $n = 27$). Twenty-seven deaths were reviewed. Of 397 recommendations made, 80% were fully implemented, 11% partially implemented, and 9% not implemented. Recommendations made related to process improvements (49%), technical changes (20%), interdisciplinary discussions (15%), educational endeavors (9%), contacting manufacturers (6%), and other issues (1%).

CONCLUSIONS: As a result of regular multidisciplinary M&M reviews being conducted, a large number of practical recommendations were made for improvements in quality of care, and implemented over a 10-year period. M&M reviews provide a useful forum for team discussions and are a vehicle for change and potential improvement in the delivery of care in a pediatric IR service.

J Vasc Interv Radiol 2009; 20:77–86

Abbreviations: ASA = American Society of Anesthesiologists, IR = interventional radiology, M&M = Morbidity and Mortality [review]

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From the SIR 2007 Annual Meeting.

This study was supported by a Society of Interventional Radiology Foundation Medical Student Research Grant. Z.S. designed, developed, and marketed the Esh-IGT database and worked with the other authors to develop functionality of the database for mortality and morbidity reviews. None of the other authors have identified a conflict of interest.

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DOI: 10.1016/j.jvir.2008.09.013

THE goals of Morbidity and Mortality (M&M) reviews (as per our hospital policy) are to (i) determine appropriateness and timeliness of the care provided; (ii) provide educational value for participants; (iii) develop new knowledge; (iv) further improve on systems and care provided; and (v) emphasize learning and prevention of similar unwanted occurrences (1).

Few studies examine the practice of M&M reviews, and the published literature is predominantly in the surgical/anesthetic specialties, with little in the radiology literature (2–9). There is evidence in the quality-assurance liter-

ature that promotion of a voluntary reporting system, a “no-blame” environment, and a “culture of safety” promotes recognition of error and interventions to correct the system, and focuses on safety improvements and change of practice (10,11). Studies on the M&M review process as an instrument of quality assurance are uncommon (12–16). M&M reviews take place in many clinical settings, but are not a widespread practice in many interventional radiology (IR) services, and the efficacy of the practice is unclear (3,7,15,17).

Pediatric IR is a relatively new subspecialty. The Hospital for Sick Children in Toronto, a tertiary referral pediatric center, has had an IR service (ie, image-guided therapy [IGT]) for many years. Monthly IGT M&M reviews have been held for more than 10 years, with the minutes recorded. Within these minutes is a wealth of information regarding the types of issues faced, the inherent risks of particular procedures, complications encountered, review of any of the deaths presented, and any of the recommendations made. Given the limited experience within pediatric IR, and the fact that IR M&M reviews are not universally practiced, there is a unique opportunity—and indeed a responsibility—to examine the practice of M&M reviews in this type of pediatric clinical service.

The primary purpose of this study was to examine our experience of conducting M&M reviews in a pediatric IR service. To do so, we first had to design a database that would enable analysis of M&M issues, both retrospectively for this review and prospectively for future audits. Our secondary purpose therefore was the creation of an electronic database for M&M issues that would facilitate this analysis and enable future tracking and prospective studies.

MATERIALS AND METHODS

Institutional review board approval was obtained for this retrospective study.

M&M Format

The practice and format of the IGT M&M reviews have evolved over the years since their inception in 1996. Not

Table 1
ASA Physical Status Classification System (20)

| Score | Description |
|------------|--|
| 1 | Normal, healthy patient |
| 2 | Patient with mild systemic disease |
| 3 | Patient with severe systemic disease |
| 4 | Patient with severe systemic disease that is a constant threat to life |
| 5 | Moribund patient who is not expected to survive without the operation |
| 6 | Patient who has been declared brain-dead whose organs are being removed for donor purposes |
| Suffix “E” | Emergency case |

all the issues submitted for M&M reviews resulted in an actual complication for the patient, so for the remainder of the present article, the cases discussed at M&M reviews are described as “issues” rather than “complications.” The M&M reviews are attended by any or all members of the IGT team (ie, registered nurses, medical radiation technologists, physicians, pediatricians) and invited guests from other divisions. Cases are collected on a voluntary reporting basis from any IGT team member or from referrals from disciplines other than radiology. At the M&M reviews, brief clinical and imaging details are presented and the issue is discussed. When appropriate, short literature reviews on relevant topics are presented by a staff member or fellow. Attempts are made to focus the conclusions of the discussions into teaching points or recommendations.

Minutes of the proceedings for 10 years (November 1996 to April 2006) had been kept on hard copy and electronically, as well as submitted to the central M&M Committee of the hospital. These minutes included details of the clinical case, discussions, and teaching points. Decisions made to change practice or take steps to improve the standard of provision of care were termed recommendations. The M&M issues ranged from minor to severe events. The deaths discussed at M&M reviews included those that were directly pediatric IR–related, indirectly pediatric IR–related, or unrelated. In addition, issues relevant to IGT were discussed, even if unrelated to the cause of death. In addition, any IR M&M case that was recognized as a critical occurrence by the hospital was identified and recorded. A critical occurrence is defined as “any occurrence

that results in an actual or potential serious, undesirable, and unexpected patient or staff outcome including death or major permanent loss of function, not related to the natural course of the patient’s illness or underlying condition” (18). These cases were investigated promptly and consistently with IGT involvement, using a “systems” approach that focuses on identifying opportunities for improvement and changes to the health care system to prevent a recurrence of the event (19).

Database

The IGT service at the Hospital for Sick Children has a sophisticated dedicated database (Esh-IGT) in which all procedures and follow-up details are entered. Each case in the database contains information regarding patient demographics, details of the procedure(s) undertaken, American Society of Anesthesiologists (ASA) physical status level (20) (Table 1), and the types of sedation/anesthesia and equipment used. For the purpose of this study, a new functionality of this database pertaining to the M&M reviews was designed and developed (by Z.S.) to be an integrated feature of each patient’s case, and was added to the existing database. After the M&M function of the database was developed, it was possible to retrospectively enter details from the M&M minutes for the appropriate case. It is important to note that ASA scores had been assigned prospectively only by anesthesiologists, and were therefore routinely available for only those patients who underwent management by an anesthesiologist. For those in the M&M population who had not required an anesthetic and therefore were without an

Table 2
Categories Used to Classify Complications/Issues Discussed at M&M Review

| Category | Description |
|---|---|
| Device-related | The complication/issue is due to a device or equipment malfunction or flaw in design |
| Ethics-related | The complication/issue is due to a philosophical, moral or ethical concern, including consent issues |
| Management-/education-/compliance-related | The complication/issue is due to a lack of education, understanding or management on the part of parents, caregivers, staff or the patient regarding care |
| Medication-related | The complication/issue is due to a side effect or deviation from the normal response to a medication |
| Near-miss/catch | A possible complication/issue was recognized and prevented, thus avoiding morbidity |
| Other | The complication/issue arose from a procedure or protocol handled in another department |
| Patient-related | The complication/issue is attributable to the patient's underlying disease, condition or comorbidity |
| Procedure-related | The complication/issue is due to technical difficulty, deviation from the normal course, omission or error during the procedure |
| Process-related | The complication/issue is due to a problem in organization, infrastructure or protocol |
| Sedation-/anesthesia-related | The complication/issue relates to any deviation from the normal course during sedation or anesthetic care |

ASA score, a score was retrospectively assigned (by P.C. and M.L.) based on their clinical history and assessments at the time. All remaining classifications were completed by B.T. and B.C. In those cases discussed at M&M review, it was possible to complete specific additional data fields pertaining to clinical history, discussion points raised at M&M reviews, and teaching points or recommendations made.

The appropriate choices (eg, category, grade, group, recommendations) were chosen from specifically designed drop-down lists to provide consistency in data entry. Classifications included the following:

Categories.—All issues brought to M&M reviews were classified into one of 10 predefined categories (**Table 2**). As many M&M issues were multifactorial in nature, each particular complication/issue could be assigned to one or more categories; this resulted in more categories than the number of individual M&M issues.

Grade.—The severity of the issue was classified according to two scoring systems. One was defined by Society for Interventional Radiology (SIR) guidelines (**Table 3**) and the other by Dindo et al (21), who developed a classification of surgical complications (**Table 4**). Not all issues discussed at M&M reviews resulted in an actual adverse outcome for the patient, so these were assigned the most minor grade available within both grading systems.

Group.—The procedures were grouped according to types, and each case was assigned to a group according

Table 3
SIR Standards of Practice Committee Classification of Complications by Outcome (18)

| Classification | Outcome |
|----------------|---|
| Minor | |
| A | No therapy, no consequence |
| B | Nominal therapy, no consequence; includes overnight admission for observation only |
| Major | |
| C | Require therapy, minor hospitalization (<48 h) |
| D | Require major therapy, unplanned increase in level of care, prolonged hospitalization (<48 h) |
| E | Have permanent adverse sequelae |
| F | Result in death |

to the procedure undertaken (eg, angiography, biopsy, enterostomy, vascular access) to facilitate analysis of M&M cases for trends, relative risks, and other statistics.

Recommendations.—Recommendations were classified into one of the six defined categories (**Table 5**). Not all discussions resulted in a recommendation; others resulted in one or more recommendations. There was no limit to the number of recommendations resulting from a discussion, and the recommendations could belong to one or more different categories.

In an attempt to evaluate the efficacy of the M&M reviews and their impact on patient care, these recommendations were examined as to whether they were implemented (yes, no, or partially).

The M&M function of the database was also designed so that specific necessary fields for each case could be compiled efficiently to create monthly

M&M reports in a format suitable for the hospital requirements. This was useful for the M&M discussion itself and also facilitated the writing and archiving of future M&M minutes.

Only descriptive statistics were employed for this study.

RESULTS

Among a total of 31,983 patient encounters, 516 patient events (294 in male patients, 222 in female patients) were discussed at M&M reviews from November 1996 to April 2006, representing 1.6% of all cases. A further 12 cases were removed from the list of M&M reviews and never discussed because of time constraints and the minor nature of the issues. The age of patients varied from premature to 24 years, with the largest proportion (22%) under the age of 1 year (**Fig 1**); this distribution is similar to that of the total pediatric IR case population.

Table 4
Classification of Surgical Complications According to Dindo et al (21)

| Grade | Definition |
|------------|---|
| I | Any deviation from the normal postoperative course without the need for pharmacologic treatment or surgical, endoscopic, and radiologic interventions; allowed therapeutic regimens are: drugs as antiemetics, antipyretics, analgesics, diuretics, electrolytes; and physiotherapy. This grade also includes wound infections opened at the bedside. |
| II | Requiring pharmacologic treatment with drugs other than such allowed for grade I complications. |
| III | Requiring surgical, endoscopic or radiological intervention |
| IIIa | No general anesthesia |
| IIIb | General anesthesia |
| IV | Life-threatening complications (including CNS complications)* requiring IC/ICU management |
| IVa | Single-organ dysfunction (including dialysis) |
| IVb | Multiorgan dysfunction |
| V | Death of patient |
| Suffix "d" | If the patient suffers from a complication at the time of discharge, the suffix "d" (for disability) is added to the respective grade of complication. This label indicates the need for a follow-up to fully evaluate the complication. |

Note.—CNS = central nervous system; IC = intermediate care; ICU = intensive care unit.
 * Brain hemorrhage, ischemic stroke, or subarachnoidal bleeding; but excluding transient ischemic attacks.

Table 5
Categories Used to Classify Recommendations Made at M&M Reviews

| Recommendation Category | Description |
|-------------------------|---|
| Discussion | The recommendation involves discussion between the IGT team and other departments involved in patient care |
| Educational | The recommendation involves a learning opportunity for parents, caregivers, staff or patients, including research |
| Manufacturer | The recommendation involves device or equipment used in interventions and can be intended for the manufacturer or medical engineering |
| Process | The recommendation involves a change in protocol or organization |
| Technical | The recommendation involves a change in technique |
| Other | The recommendation involves another department |

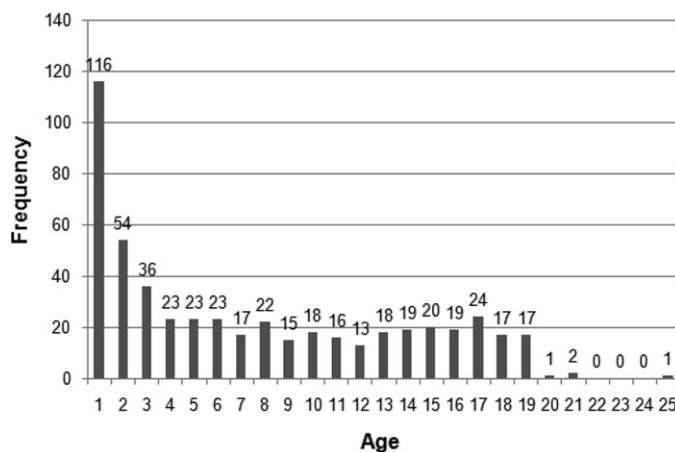


Figure 1. Age range of patients discussed at M&M reviews.

Patients discussed at M&M reviews ranged in weight from 0.4 kg to 105 kg, and the male-to-female ratio was 1.3:1.

Based on the definitions in Table 2, each of the 516 M&M occurrences were assigned to one or more category of issue, resulting in 772 categories in all.

Three hundred and five were assigned to one category, 173 were assigned to two categories, 32 were assigned to three categories, five were assigned to four categories, and one was assigned to five categories. Evaluation of the categories assigned to the issues (N = 772) is shown in detail in Figure 2, with the most common three being procedure-related (34%), patient-related (20%), and process-related (15%).

The distribution of cases according to the SIR guidelines and the surgical classification is shown in Figures 3 and 4, with more than 50% in both being deemed minor. A second peak is seen in major category D, grade IIIb, mainly because of the frequent need for sedation/general anesthesia for many repeat procedures in children—albeit often minor procedures—as well as any increase in level of care (not just intensive care) or potentially prolonged hospitalization.

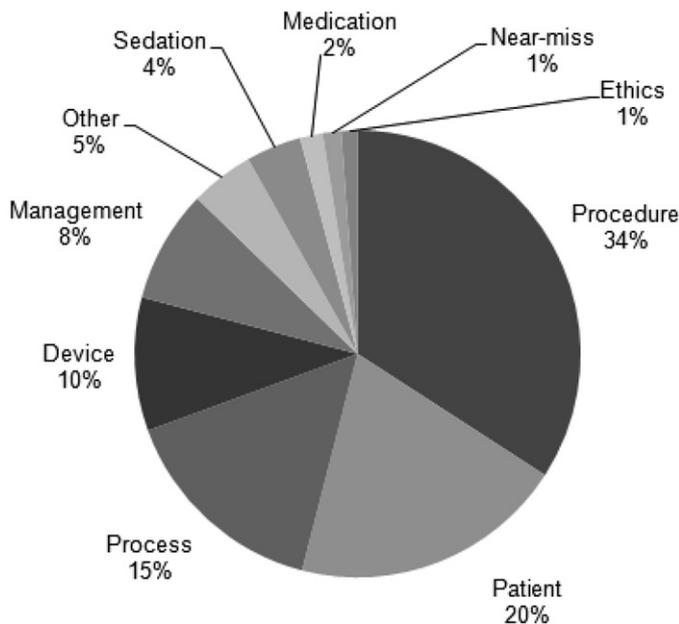


Figure 2. Distribution of categories ($N = 772$) assigned to 516 issues discussed at M&M reviews.

Of the total case population from the same time period ($N = 31,983$), ASA scores were not available in 29,596 cases (because cases performed without an anesthesiologist present have no ASA score assigned at the time of the procedure). The distribution of ASA scores that were available in the total population was similar to that in the M&M population, but it appears that proportionately fewer patients with an ASA score of 1 were brought to M&M than those with higher ASA scores (Fig 5). Given the large number of patients whose score is unknown in the total population, further interpretation would only be speculative.

Among the 516 issues discussed, there were 27 deaths reviewed (IR-related and unrelated). Of these, 31% of issues related to the procedure, but patient comorbidity (18%) and errors in process (17%) were also identified as the reasons for presentation at M&M reviews (Fig 6). The distribution of categories among the total M&M population (Fig 2) was similar to that found among the deaths discussed (Fig 6). Three of these deaths were managed as critical occurrences. These cases were documented and investigated promptly at a hospital level in combination with the IGT department (19).

Of the 516 cases discussed at M&M reviews, there were 241 in which no specific recommendation was made and no change of practice was adopted. In the remaining 275 cases, a total of 397 recommendations were made (Fig 7). These discussions could result in recommendations reflecting wider aspects relevant to but beyond the event itself. Discussion at M&M reviews resulted in one recommendation in 194 instances, two recommendations in 64 instances, three recommendations in 11 instances, four recommendations in three instances, and five, six, eight, and 13 recommendations in one instance each. Of these, 80% were fully implemented, 11% were partially implemented, and 9% were not implemented. Recommendations ($N = 397$) were related to process improvements in 49%, technical changes in 20%, multidisciplinary discussion in 15%, educational endeavors in 9%, contacting manufacturers in 6%, and other tasks in 1% (Table 6). Because cases with similar occurrences were occasionally grouped together for discussion, several of the recommendations applied to more than one patient, as the recommendations were made for the whole group.

In addition, 516 points brought up during M&M discussions were identified and classified as teaching points.

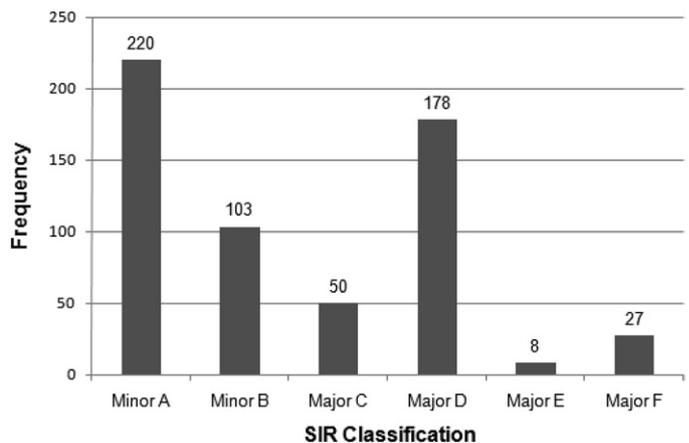


Figure 3. Distribution of complications classified according to SIR guidelines (18).

These were useful tips for team members, made by those with more experience for the benefit of trainees or by visiting attendees from other disciplines.

To test the search capabilities of the M&M function within the Esh-IGT database, an analysis of the incidence of M&M issues occurring in different groups of procedures (eg, biopsies, enterostomy access, and venous access) was undertaken (Table 7). This simple search provides an overview of the relative risks of some common IGT procedures, and is indicative of the search capabilities of the system for future studies.

DISCUSSION

This retrospective analysis of pediatric IR M&M reviews provides an overview into the practice of M&M reviews in a pediatric interventional environment. It lends insight into the range and types of issues encountered. Importantly, it involved the creation of a tool for future tracking and analysis of M&M issues.

Development of this M&M functionality of the database permits analysis of data into groups of procedures. A wide variety of searches are now possible that will provide information into the relative complexity of proce-

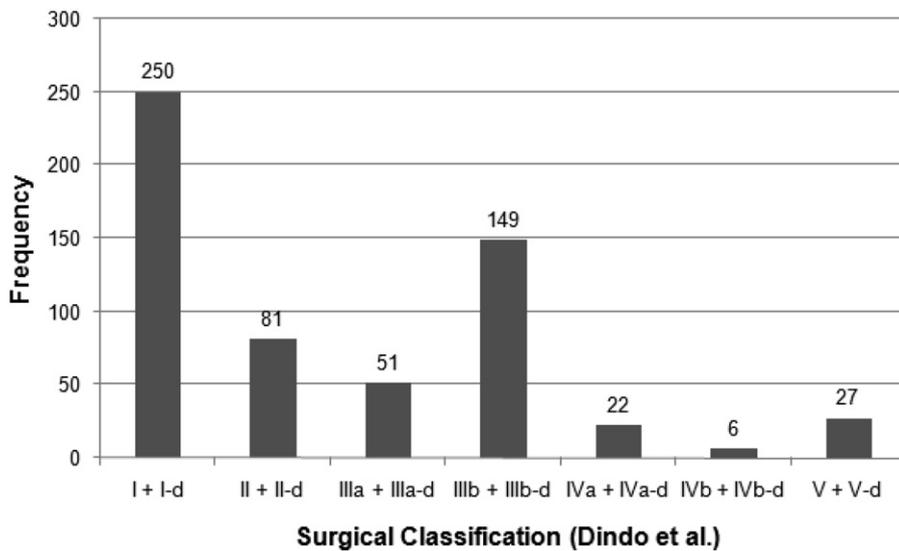


Figure 4. Distribution of complications classified according to Dindo et al (21).

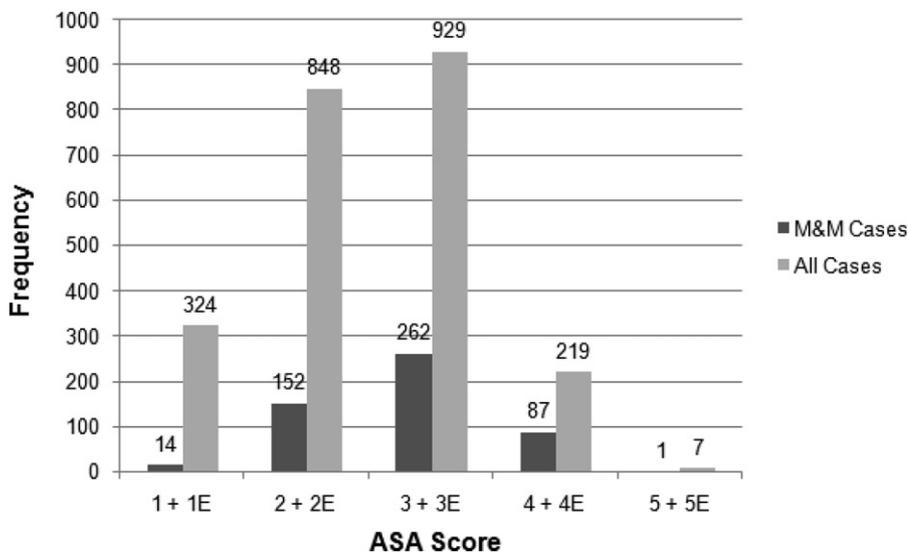


Figure 5. Distribution of ASA scores.

dures, medical fragility of patients, comorbidities, inherent risks of the procedure, and operator skill level and familiarity with a procedure. Prospectively, it may enable actual improvement in patient care to be measured by identifying and analyzing the implementation of specific recommendations or changes in clinical practice that resulted from the M&M reviews. The results from these searches may help determine much needed thresholds for complications in pediatric IR for certain procedures.

The classifications defined by SIR (18) and Dindo et al (21) proved to be useful tools, as both systems yielded

comparable results (ie, similar proportions of major and minor complications). The criteria were applied strictly, erring on the side of overestimating rather than underestimating the severity. The majority of complications were rated minor by both classifications: SIR grade A (39%) or grade B (17%) and Dindo et al (21) grade I (45%) or II (13%). However, there was a peak in the number of major complications (SIR grade D and Dindo et al [21] grade IIIb) reflecting the fact that, inherent to a pediatric IR service, children require sedation and/or general anesthesia more often than adults on a per-procedure basis. Therefore, pa-

tients who required another procedure, albeit a minor one with little or no ill effects, were classified as having a grade D/grade IIIb complication if they needed sedation or general anesthesia, an increased level of care, or prolonged hospital stay. As some of the issues discussed resulted in no adverse outcome for the patient, they could be assigned only the most minor grade available (SIR grade A or grade I), even if it was not an actual complication. As a result of both these factors, the current grading systems of complications may not be entirely suitable for pediatric practice (ie, given the high rate of SIR grade D/grade III complications), and this may require some modification in the future.

Morbidities and mortalities were most often related to the procedure undertaken. It is important that a cause is identified if possible so changes in technique can be identified to improve future outcomes. The second most common factor identified related to patient comorbidity. Unfortunately, this is a factor that cannot be avoided altogether, but rather can be optimized. Time, care, and attention to detail are important so that patient optimization is attempted. After thoughtful review, analysis, and team discussions at M&M reviews, changes in preprocedural workup and preparation, as well as postprocedural care orders, have been implemented to avoid recurrences of identified issues. It is interesting to note that patient-related and process-related causes of morbidity presented in equal proportion in minor and major complications, so no one factor seemed to be responsible for major difficulties encountered (Fig 8).

In the context of this retrospective review, implementation of recommendations was the only measure available to assess the efficacy of the practice of M&M reviews. Given the number of recommendations that were implemented (80%), it suggests that the pediatric IR M&M process may be a useful method for improving quality assurance in an IR service. This requires prospective study or audits. Unlike other disciplines in which the emphasis may be placed on mortality, minor and major complications were discussed equally and focused on process changes as well as technical or

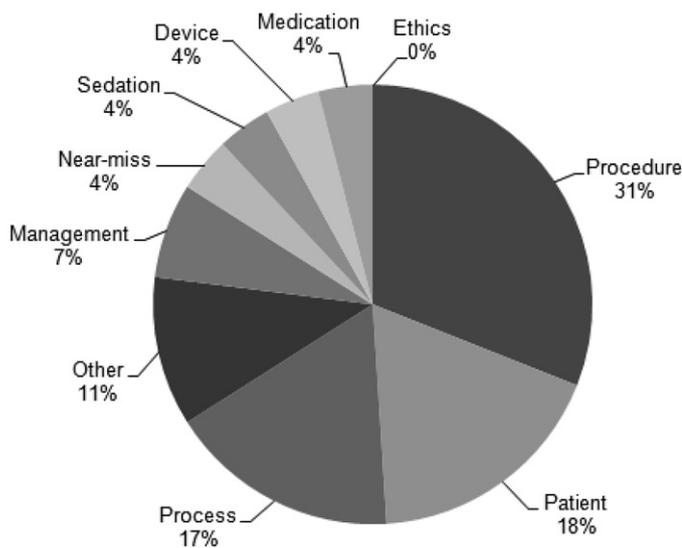


Figure 6. Distribution of categories among deaths reviewed at M&M reviews.

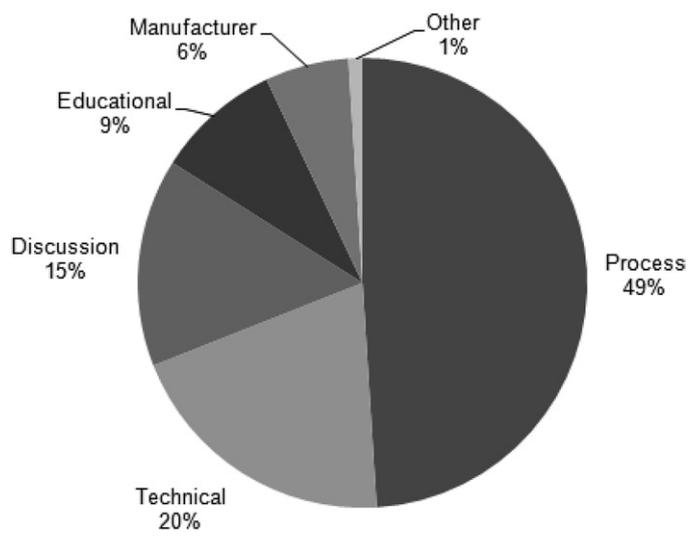


Figure 7. Distribution of the recommendations (N = 397) made in 275 of the 516 instances.

procedural issues. Recommendations from any one issue could vary in number and category. With respect to the recommendations made, a majority were process-related, encouraging practical changes in protocol and organization within the IGT department. The highest proportion of recommendations that were only partially implemented were also process-related, which may reflect the difficulties encountered when changing processes at a hospital-wide level. The highest proportion of recommendations that were not implemented related to contacting manufacturers and requesting changes in equipment or device design. These ideas and suggestions tend to fall outside of the direct control of the IR service and into the domain of the manufacturer. Research, development, and design modification are not quick fixes and may take a significant amount of time to implement. In addition, many manufacturers view the pediatric portion of the IR market as very small, without much financial incentive for change. Conversely, almost every technical recommendation was implemented, which indicates that M&M reviews promoted change in practice aimed at improving patient outcomes. Recommendations and suggestions made to undertake multidisciplinary discussion to resolve a problem, research projects, and educational topics were usually undertaken. In

fact, an educational lecture series was developed to accommodate topics raised at M&M reviews, with suitable speakers suggested by team members.

Given the time and effort required to conduct M&M reviews, why should a pediatric IR center put them into practice? There are several benefits, not just simply in learning from errors. Through M&M discussions, there is opportunity to formulate simple and practical changes that can be easily implemented and are designed to improve delivery of patient care with buy-in from team members. M&M reviews also result in increased knowledge about specific patient populations and risk factors. Members of the team become conscious and alert regarding the inherent risks because they have been highlighted in M&M discussions. In addition, M&M reviews promote education of fellows and staff as well as other team members (eg, registered nurses and medical radiation technologists). By sharing tips and solutions to problems during discussions, more uniform practice is promoted, leading to standardization of procedures and greater efficiency. Communication is enhanced, as M&M reviews provide a meeting forum for the team, and also with other invited disciplines. This provides learning opportunities from other disciplines, preventing the pediatric IR service from becoming too insular.

There are several limitations to this review. It is retrospective in nature, and some M&M issues—and even deaths—may not have been identified at the time or brought for review. The 516 events reported here therefore likely represent an underestimate and cannot be viewed as an exhaustive list of all problems encountered. This is especially true of the earlier years of the study, before routine ward rounds and outpatient follow-up phone calls constituted normal practice in the IGT department. Capture of M&M cases is now better as a result of several factors: daily ward rounds, follow-up phone calls, and the new electronic method of identifying cases and issues in the database as they arise. Capture of cases has also been enhanced because of team perception of the M&M review process as a meaningful, relevant, practical method for improvement of service and a forum for team discussions on different aspects of patient care. As a result, there are now more issues identified than can be discussed at a monthly meeting. This may require more frequent M&M reviews in the future, or an additional alternative forum. Another limitation is that our data could be challenged, as some issues do not represent actual individual patient morbidity, but rather “near-misses” and process issues that were identified as requiring discussion to improve the delivery of

Table 6
Examples of Issues and their Categories, the Recommendations Arising, and the Category of Recommendation

| Issue | Issue Category | Recommendation | Recommendation Category |
|--|--|---|-------------------------|
| Cecostomy tube (short) present for several years, coils hardened and stuck in tract. Difficulties during tube change; Wire stuck using 035-inch straight wire, severe pain, unable to remove tube | Procedure-related; device-related | 1. Use Glidewire when change is difficult | Technical |
| | | 2. Deploy old tube into cecum to be later passed PR, rather than remove it externally | Technical |
| | | 3. Arrange patients to return for annual tube change | Process |
| | | 4. Advocate manufacturer to design medium length trapdoor tube | Manufacturer |
| Left lung abscess drainage in 2-year-old patient; profound desaturations with spill of pus into contralateral lung, up and over bronchus; anesthetist had difficulty accessing the patient during episode because of position of C-arm | Procedure-related; sedation-/ anesthesia-related | 1. Avoid positioning patient with uninvolved side down – supine position is better. | Technical |
| | | 2. Gentle use of wire to avoid excess manipulation of abscess cavity. | Technical |
| | | 3. Plan appropriate set up of room (side of C-arm, side of anesthetist etc) in advance of case, bearing in mind access for the anesthetist. | Process |
| Hypothermia and skin burn from prep solution in premature ELBW infant (650 g) during PICC placement | Patient-related; procedure-related | 1. Warming strategies with NICU transport team discussed and planned (“Bair Hugger,” chemical warming blanket, etc). | Discussion |
| | | 2. Avoid excess puddling of cold scrub solution. | Technical |
| | | 3. Use 0.5% chlorhexidine solution in the ELBW infants instead of 2% | Technical |
| | | 4. IR personnel to accommodate intermittent assessments by NICU transport team to ensure patient is dry/warm | Process |
| | | 5. Plan for lecture to IGT team about risks of ELBW infants | Educational |

Note.—ELBW = extreme low birth weight; NICU = neonatal intensive care unit; PICC = peripherally inserted central catheter.

patient care. The practice of the reviews themselves has evolved over the years and has likely varied in format and rigor, with the minutes being more detailed in recent years. On occasion, a case flagged for discussion at M&M was overlooked. This reflects the fact that no process can be perfect, and we hope the new electronic system of flagging cases for M&M review developed during this project will reduce the number of missed cases. In addition, an important limitation of this review is that, given the retrospective nature of the study, it was not possible to actually measure improvement in patient care. The only measure of effectiveness of the process that we are able to apply was assessment of the number of recommendations implemented.

Despite these limitations, we have found incorporation of certain ele-

ments to improve the value and efficacy of the M&M reviews. First, it is important to have all members of the pediatric IR team participate in M&M reviews with equal voice. Second, deciding on take-home points or recommendations at the conclusion of each case helps focus the discussion. Grouping of patients with similar complications/issues for discussion at a single M&M review makes the review process more efficient, but perhaps at the expense of individual patient detail. In addition, encouraging multidisciplinary discussion and participation by inviting relevant persons to attend is very educational and productive. We have also found inviting guest speakers to give a lecture on specific educational topics to be rewarding.

In the future, continued development of the M&M functionality of the database will make it possible to

track trends, types of issues, and groups or prevalence of complications over time. In addition, issues involving individual staff members and patients can be monitored, and recommendations can be tracked over time to ensure implementation. This will facilitate understanding of the causes and factors related to M&M issues. A major advantage will be the versatile search capabilities of many aspects of M&M reviews, which provide the capability to gather, analyze, and publish future reports on different aspects of IR-related morbidity and mortality, such as thresholds and relative risks of different variables to be examined (eg, age, prematurity, ASA score, procedure type, physician). In the future, by identifying issues and solutions, one may be in a position to prospectively audit or measure any actual improvements

Table 7
Interventional Procedures and Occurrences at M&M Review, 1996–2006

| Type/Procedure | Total Cases | M&M Reports | Major | Minor |
|------------------------------|-------------|-------------|-------|-------|
| Biopsy | | | | |
| Mediastinum | 47 | 3 (6.4) | 0 | 3 |
| Liver transjugular | 97 | 6 (6.2) | 3 | 3 |
| Abdominal mass | 38 | 2 (5.3) | 0 | 2 |
| Adrenal mass | 81 | 4 (4.9) | 1 | 3 |
| Liver mass | 48 | 3 (6.3) | 2 | 1 |
| Kidney mass | 31 | 1 (3.2) | 1 | 0 |
| Lung | 93 | 4 (4.3) | 1 | 3 |
| Liver | 878 | 22 (2.5) | 6 | 16 |
| Bone | 159 | 2 (1.3) | 2 | 0 |
| Liver transplant | 277 | 3 (1.1) | 1 | 2 |
| Kidney | 608 | 4 (0.7) | 0 | 4 |
| Enterostomy | | | | |
| C tube insertion | 209 | 14 (6.7) | 8 | 6 |
| Gastrojejunal tube insertion | 155 | 12 (7.7) | 6 | 6 |
| Gastric tube insertion | 1,228 | 67 (5.4) | 35 | 32 |
| Venous access | | | | |
| CVC insertion | 1,183 | 49 (4.1) | 22 | 27 |
| Port insertion | 815 | 21 (2.6) | 11 | 10 |
| PICC insertion | 2,931 | 85 (2.9) | 37 | 48 |

Note.—Values in parentheses are percentages. CVC = central venous catheter; PICC = peripherally inserted central catheter.

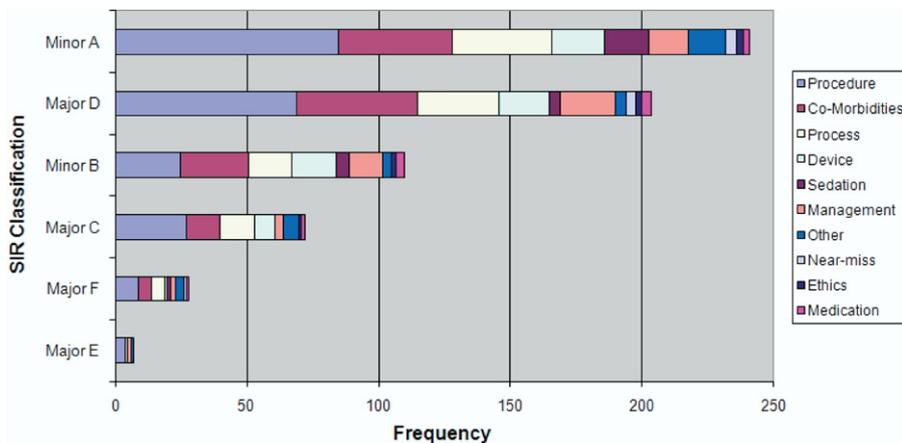


Figure 8. Distribution of categories for each SIR classification of M&M issues.

achieved in patient care. As mentioned earlier, one simple overview example is shown in **Table 6**, which highlights the relative risks associated with different procedures. In addition, storing this data electronically enables review of the results of the M&M discussion, as well as outcomes, recommendations, and teaching points linked to any specific case, by any member of the pediatric IR team at any time.

The results of this project appear to validate the M&M process and its essential role for quality assurance in IR.

This project attempted to assess the efficacy of M&M reviews in a pediatric IR service and its positive impact on patient care. This project can be viewed as a step forward in helping to establish M&M standards for procedures in pediatric IR.

Acknowledgments: The authors gratefully acknowledge the support of the SIR Foundation Medical Student Research Grant awarded to B.T. for completion of this project. Jennifer Vaughan provided invaluable secretarial support for this project.

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