Evaluation of an electronic health record structured discharge summary to provide real time adverse event reporting in thoracic surgery

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ABSTRACT

Background The reporting of adverse events (AE) remains an important part of quality improvement in thoracic surgery. The best methodology for AE reporting in surgery is unclear. An AE reporting system using an electronic discharge summary with embedded data collection fields, specifying surgical procedure and complications, was developed. The data are automatically transferred daily to a web-based reporting system.

Methods We determined the accuracy and sustainability of this electronic real time data collection system (ERD) by comparing the completeness of record capture on procedures and complications with coded discharge data (administrative data), and with the standard of chart audit at two intervals. All surgical procedures performed for 2 consecutive months at initiation (Ti) and 1 year later (T1yr) were audited by an objective trained abstractor. A second abstractor audited 10% of the charts.

Results The ERD captured 71/72 (99%) of charts at Ti and 56/65 (86%) at T1yr. Comparing the presence/absence of complications between ERD and chart audit demonstrated at Ti a high sensitivity and specificity, positive predictive value (PPV) of 95.5%, negative predictive value (NPV) of 93.9% with a kappa of 0.872 (95% CI 0.750 to 0.994), and at T1yr a sensitivity, specificity, PPV and NPV of 100% with a kappa of 1.0 (95% CI 1.0). Comparing the presence/absence of complications between administrative data and chart audit at Ti demonstrated a low sensitivity, high specificity and a kappa of 0.471 (95% CI 0.256 to 0.686), and at T1yr a low sensitivity, high specificity of 85% and a kappa of 0.479 (95% CI 0.245 to 0.714).

Conclusions We found that the ERD can provide accurate real time AE reporting in thoracic surgery, has advantages over previous reporting methodologies and is an alternative system for surgical clinical teams developing AE reporting systems.

INTRODUCTION

In 1966, Donabedian proposed the evaluation of the quality of healthcare using the triad of structure, process and outcomes. A key component of outcome measurement within a surgical programme is to determine the frequency and severity of adverse events, such as postoperative morbidity and mortality. The ideal method to capture short-term clinical outcomes, such as complications, remains unclear.

A variety of options presently exist for adverse event reporting, but none are considered ideal.[1] Administrative data collection typically using International Classification of Diseases (ICD) coded information is one option. A persistent concern is discordance between the results of administrative data and clinical registries, resulting in challenges from clinical teams with regard to validity,.[2 3] Chart audit methods are commonly used, but they are labour intensive and expensive. The popularity of electronic health records has led to an exploration of the use of natural language processing to search for keywords to identify surgical adverse events, but this tool has not yet gained wide spread experience,.[4] Voluntary reporting methods, such as incident reporting, are thought to be ineffective for a variety of reasons, including the interruption of workflow required to document adverse events.

The evolution of electronic medical records has the potential to address some of the limitations of present adverse event reporting systems. Structured or synoptic clinical documentation has been reported to enhance the reporting of factors that are thought to be important for prognosis and treatment decisions

in both pathologic and operative reporting of cancer care.[5] Similarly, structured clinical documentation could enhance adverse event reporting quality. The maturing of electronic health records has allowed for structured clinical documentation within components of mandatory workflow, such as the discharge summary. Embedding adverse event reporting within the clinical workflow could improve the likelihood of data entry, thus addressing one of the perceived barriers of voluntary reporting systems. Once clinical data are structured within the electronic record, it supports immediate transfer to reporting dashboards. Timely reporting of metrics is thought to be important in quality improvement.[6] Therefore, we developed an electronic real time data collection system (ERD), which consists of embedded data collection fields in an electronic health record discharge summary that automatically reports to a web-based dashboard system. The ERD provides for adverse event reporting within the clinical workflow in real time.

The purpose of our study was to investigate the ability of the ERD to report complete and accurate information for both thoracic surgery operative procedures and complications/adverse events encountered. The ERD generated data were evaluated by comparison to both data from discharge abstract data (administrative data), and to data generated by the gold standard of chart audit.

MATERIALS AND METHODS

An electronic discharge summary with embedded data collection fields specifying surgical procedure and adverse events (complications) was developed by the section of Thoracic Surgery and Clinical Informatics team of a tertiary teaching hospital. The electronic discharge summary was contained within the hospital's electronic health record system, Allscripts Sunrise Enterprise Release 15.1 (Sunrise Clinical Manager). Data entry into the electronic discharge summary was done by any member of the thoracic surgery team, including staff surgeons, surgical residents and nurse practitioners. Data could be entered at any point in the patient's hospitalisation. The majority of the data entry was done by the nurse practitioners during the weekdays, with completion of the discharge summaries on the weekend by surgical residents and surgeons. The completion of discharge summaries is mandatory in our hospital setting but the bylaws do not mandate completion of the discharge summary prior to patient discharge.

The most common thoracic surgical procedures are available in tick boxes and drop-down menus within the discharge summary. The most common adverse events are also available in tick boxes within the discharge summary. The entry of an adverse event within the discharge summary resulted in the opening of a structured field with grades of complications being available to select. The complications were classified and graded, adopting the system of Seely *et al* at the University of Ottawa[7] (see figure 1).

A web-based reporting system using Tableau Desktop Professional and Tableau Server (V.10.1) from Tableau Software was developed. The dashboard displayed the surgical procedures, surgical complications and mortalities captured within the discharge summary. The dashboard was scheduled to update on a daily basis (see figure 2).

Following a 1-month period to familiarise staff with the ERD, 2 consecutive months were chosen to compare ERD-generated metrics with both the gold standard of chart audit and with the routinely collected administrative data. The data generated by the ERD were compared with the chart audit to determine the completeness of record capture. The proportion of patients identified to have a complication by the ERD was compared with the gold standard chart audit using χ^2 analysis to calculate sensitivity, specificity, positive predictive value and negative predictive value. The kappa statistic was also calculated to indicate the level of agreement. A similar comparison of the ERD data to routinely collected administrative data was done. The specific nature of the complication as identified with the ERD was then compared with the gold standard of the chart audit. To determine if the performance of the clinical team and ERD was sustainable, the analysis was repeated 1 year later. The 2 consecutive months following initiation of the ERD will be denoted as Ti, and the 2 consecutive months 1 year later will be denoted as T1yr.

The data for the gold standard of chart audit were derived by an experienced and trained chart abstractor who had access to both the paper and electronic health record. The electronic health record was used to search all encounters of the thoracic surgeons for the 2-month study period. A list of encounters was generated, which included patient's identifiable information, admit date and provider information. The generated list was then used to search for a thoracic surgical procedure. For all encounters that did not state a surgical procedure, records were individually searched to confirm the presence or absence of a surgical procedure.

After the initial round of chart review, a crosscheck of individual identifying numbers with the ERD was done to identify additional charts for further review. The information obtained from the paper and electronic chart was admission date, surgery date, surgeon, surgical procedure, and complications indicated in the progress notes, operative notes, results from the laboratory and radiology, discharge summary and transfer summaries.

A second experienced and trained chart abstractor independently reviewed 10% of the charts in both time periods of Ti and T1yr. The data from both chart abstractors were then reviewed together to identify and resolve any discrepancies, and to ensure that both

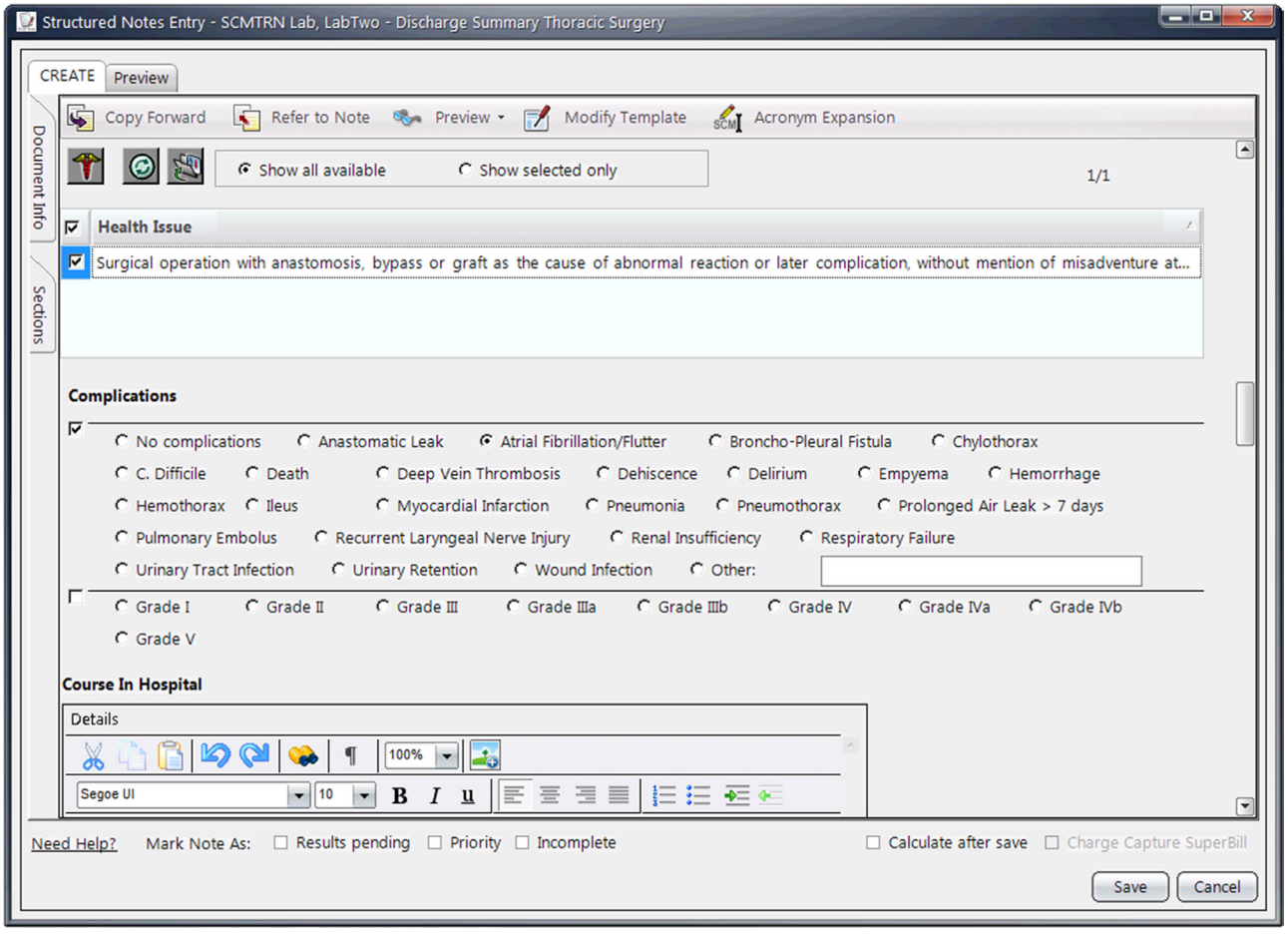

Figure 1 Structured discharge summary.

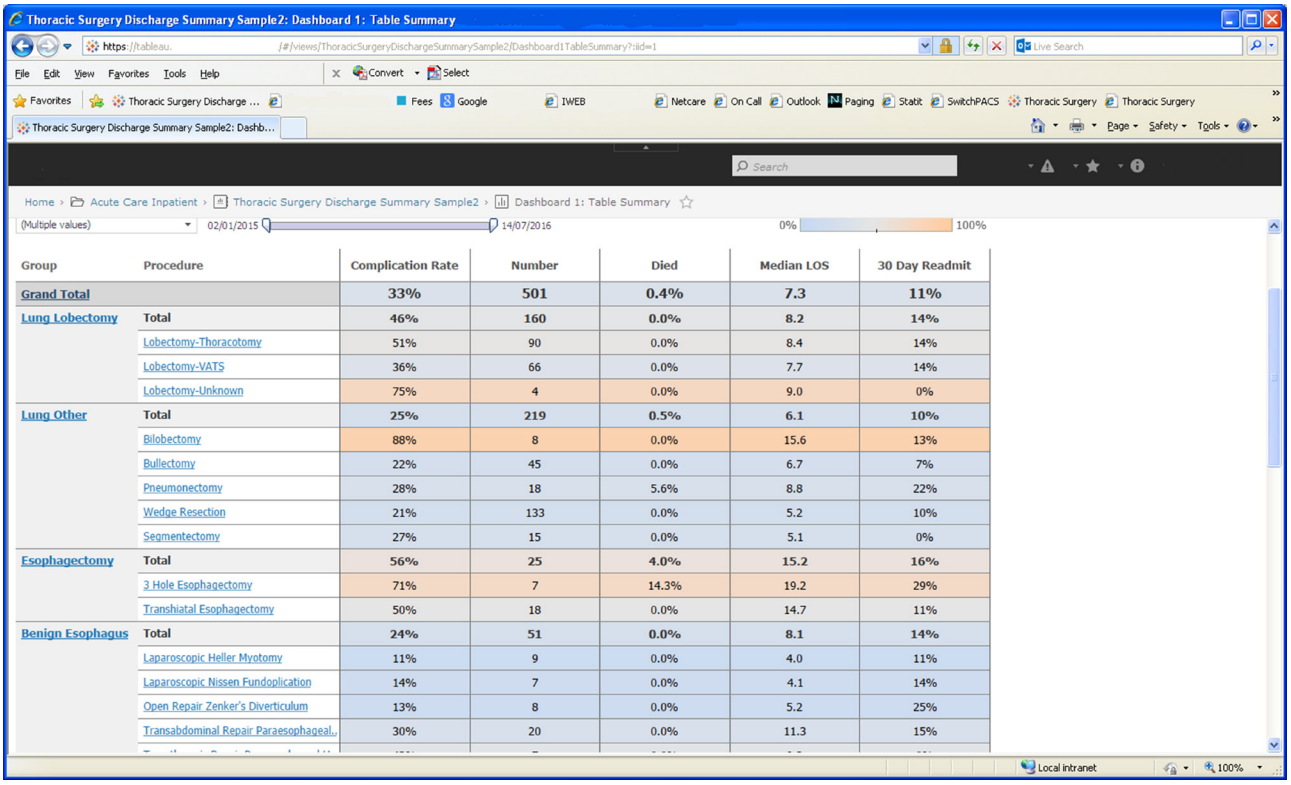

Figure 2 Web-based reporting of electronic real time data collection system (ERD).

abstractors were obtaining and interpreting the same information.

Administrative data were requested and obtained from our Health Information Management department on patients who had a thoracic surgical procedure in both 2-month study periods. The data included the unique identifying number, diagnosis codes (ICD-10-CA), procedure codes (ICD-10-CA) and complication flags that are automatically generated from the diagnosis codes and used for a static quarterly report for thoracic surgery. The complication flags were manually validated with the diagnosis codes to ensure accurate capture of the data.

Consistent with the standards set out in the Tri-Council Policy Statement, this project was considered exempt from the research ethics review requirement as it was a quality assurance/programme evaluation activity to be used for assessment, management and/or improvement of thoracic surgical outcome reporting.

RESULTS

The initiation data collection interval at Ti identified 88 eligible encounters in the 2-month collection period. Sixty-five eligible encounters were identified for the 2-month period 1 year later at T1yr. Fifteen encounters in Ti and one encounter in T1yr were excluded as the procedures were done through day surgery, for which no discharge summary is required. The ERD captured 98.6% of surgical encounters in Ti and 86.2% in T1yr (see figure 3). Analysis of nine missed encounters revealed that all encounters had been entered into the ERD via the discharge summary, but were not displayed. These procedures were not displayed as they were operative procedures rarely performed. The ERD displays a core set of 19 procedures.

There were no discrepancies in data collected between the two chart abstractors, which indicated a full agreement. The ERD identified those patients with one or more complications, or no complications with a high degree of sensitivity and specificity. Furthermore, the performance of the ERD was maintained and improved at the T1yr interval, as indicated by the kappa statistic from 0.87 at Ti to 1.0 at T1yr (see table 1). The administrative data, meanwhile, showed a low sensitivity and high specificity to the chart audit at both time intervals. The kappa statistic for administrative data compared with the chart audit was consistent at both intervals, where the kappa was 0.47 at Ti and 0.48 at T1yr (see table 2).

Analysis with regard to type of complication was undertaken. In the initiation cohort, 21 patients suffered one or more complications. A total of 32 complications were identified. The type of complication identified disagreed with the gold standard in two

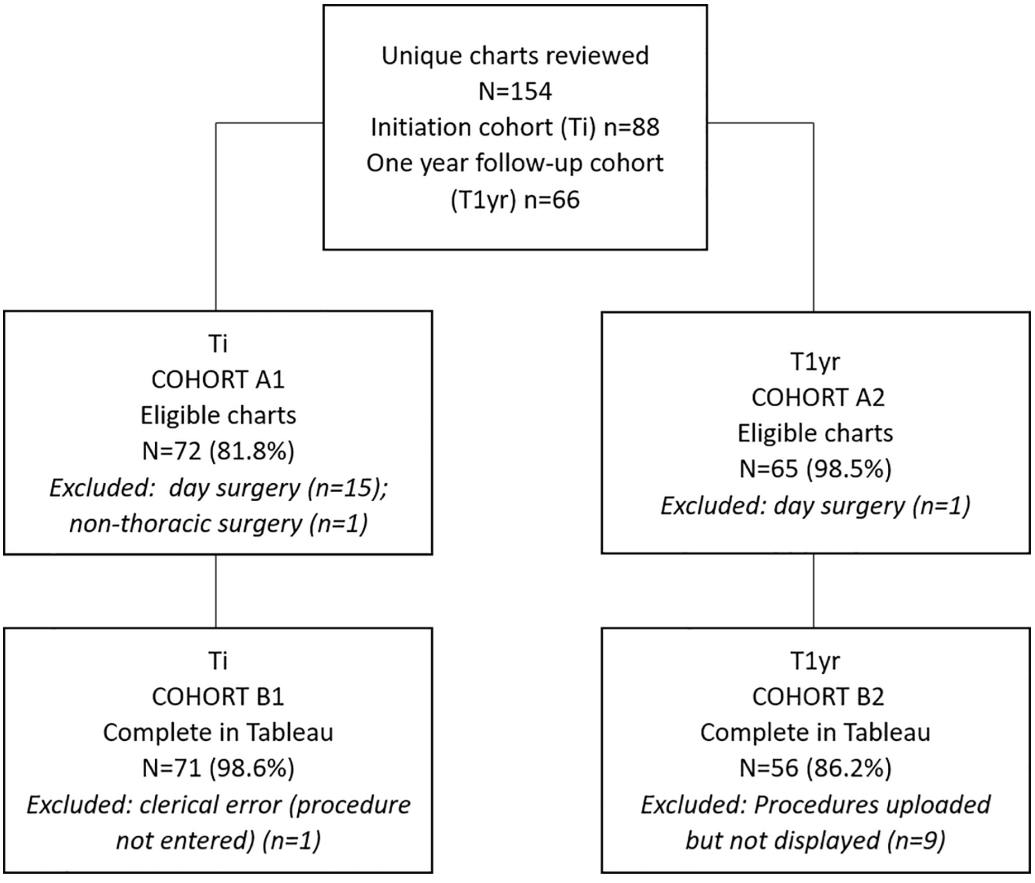

Figure 3 Flow chart demonstrating record capture.

Table 1 Comparison of surgical cases with or without complications identified by ERD and chart audit

A. Initiation cohort (Ti)

	Chart audit			
ERD	**Complications**	**No complications**	**Total**	
Complications	21	1	22	PPV=95.5%
No complications	3	46	49	NPV=93.9%
Total	24	47	71	
	Sensitivity=87.5%	**Specificity= 97.9%**		

B. One-year follow-up cohort (T1yr)

	Chart audit			
ERD	**Complications**	**No complications**	**Total**	
Complications	18	0	18	PPV=100.0%
No complications	0	38	38	NPV=100.0%
Total	18	38	56	
	Sensitivity=100.0%	**Specificity=100.0%**		

Kappa=0.872 (95% CI 0.750 to 0.994).
Kappa=1.00 (95% CI 0.92 to 1.00).
ERD, electronic real time data collection system; NPV, negative predictive value; PPV, positive predictive value.

cases. An analysis of the discordance demonstrated minor differences (eg, urinary retention vs urinary tract infection).

Analysis of the four patients in the Ti cohort, where the ERD did not identify the presence of a complication, revealed that in two cases the complications were identified at the time of readmission. The complications identified for these two patients were an empyema and a pulmonary embolism. For the other two patients, the status of presence or absence of complications was not correctly identified. One case revealed the failure to document the status of no complications. For the other case, an assessment by a clinical team found that the patient's hospital course was too complex; therefore, the discharge summary was dictated instead of using an electronic discharge summary.

In the 1-year follow-up cohort, 18 patients suffered one or more complications. A total of 23 complications were identified. In a single case, the chart audit documented a patient encounter with three complications and the ERD documented only two complications. Otherwise, agreement was complete with regard to the specific type of complication. Similar to the initiation cohort, one case revealed the failure to document the status of no complications.

DISCUSSION

We found that an electronic discharge summary with embedded data fields and automatic web-based reporting system captured 92% of cases. This demonstrates that a clinical team can use this reporting method in their workflow, and thus provide data to identify surgical procedures and short-term adverse events. The ERD methodology, in comparison to a chart audit of the complete medical record, identified those patients who did or did not suffer a complication with a specificity

Table 2 Comparison of surgical cases with or without complications identified by administrative data and chart audit

A. Initiation cohort (Ti)

	Chart audit			
Administrative data	**Complications**	**No complications**	**Total**	
Complications	11	2	13	**PPV=84.6%**
No complications	13	46	59	**NPV=78.0%**
Total	24	48	72	
	Sensitivity=45.8%	**Specificity=95.8%**		

Kappa=0.471 (95% CI 0.256 to 0.686).

B.One-year follow-up cohort (T1yr)

	Chart audit			
Administrative data	**Complications**	**No complications**	**Total**	
Complications	12	7	19	**PPV=63.2%**
No complications	7	39	46	**NPV=84.8%**
Total	19	46	65	
	Sensitivity=63.2%	**Specificity=84.8%**		

Kappa=0.479 (95% CI 0.245 to 0.714).
NPV, negative predictive value; PPV, positive predictive value.

of 97.9% and sensitivity of 87.5%. A kappa statistic of 0.872 demonstrated excellent agreement with the gold standard, indicating the ERD methodology as a reliable way to identify patients with complications.

The ERD methodology was also demonstrated to be sustainable. At a follow-up of 1 year the ERD continued to identify accurately those patients with or without complications compared with chart audit as demonstrated by kappa statistic of 1.0.

The ERD was found to consistently be superior to administrative data in accurate identification of patients with or without complications. Administrative data demonstrated a lower sensitivity and measure of agreement with the gold standard.

Our results are consistent with and extend to those reported by Salati *et al*, who compared electronic health record data and a traditional data base from the standpoint of missing data values.[8] Consistent with our findings, little difference in the proportion of missing data values was noted when comparing the two data source systems. However, agreement between the two data sources was not reported in their study.

Advantages

The use of an electronic discharge summary with embedded data collection fields to provide adverse event reporting has a number of advantages compared with other methodologies of adverse event reporting. Our reporting system, using the classification of methodologies by Murff *et al*, is a voluntary manual method of reporting.[1] Reporting systems using these methodologies have been considered not to be the most effective methods of adverse event reporting. This may, in part, be due to the requirement of interruption of workflow, which could possibly result in under-reporting of adverse events. The embedding of the reporting system within the discharge summary appears to mitigate this barrier to data entry, as demonstrated by our 92% capture rate.

For adverse event reporting to facilitate quality improvement, the clinical team needs confidence in the accuracy of the reporting system. Our methodology has the advantage of being able to more accurately determine both those patients who suffer an adverse event and the specific nature of the complication, when compared with administrative data. Murff *et al* have noted that the 'gold standard' for the determination of an adverse event has traditionally been implicit physician judgement.[1] Our methodology has the clinical team to determine and enter the complications, thus eliminating the need for assessment by an observer without clinical expertise. We believe this is the likely explanation for the increased agreement of our methodology with the detailed chart review. In contrast, administrative data are entered by non-clinical team members, therefore, the translation of the chart information may be misinterpreted. We believe the ERD methodology of adverse event reporting facilitates the entry of data by clinical experts, and thus enhances data accuracy.

Our methodology appears to have an advantage over another commonly used involuntary reporting method, the chart audit. The greatest limitation of the chart audit is thought to be the overall resources required. The resulting high cost of routine adverse event reporting derived from chart audits is therefore thought to be impractical. Although not formally examined, our methodology, after initial development, does not require ongoing resources. The data are collected and entered by the clinical care team as part of its normal workflow, and the dashboard is automatically updated without additional resources being required. Therefore, this methodology may be useful in cost-constrained environments.

A further potential advantage of our methodology is the real time updating of data reporting. The transfer from the electronic discharge summary to the web-based dashboard occurs daily. The ideal reporting interval is likely variable depending on the clinical situation. However, monitoring of adverse events during new quality improvement initiatives should have timely reporting to detect improvements and monitor for unintended consequences.

Limitations

The accurate and timely completion of the discharge summary is critical to the success of the ERD. The data are entered at multiple times during the course of the patient's hospitalisation. The majority of data entry is done by nurse practitioners, with a smaller portion being added by staff surgeons or house staff. The results may not be generalisable if nurse practitioners are not part of the clinical team, and if more of the data entry falls to staff surgeons. Furthermore, training of the clinical team on the process of discharge summary completion is an ongoing requirement. However, ongoing training requirements are inherent to any clinical data collection system.

Unlike other adverse reporting systems, such as data reported from the National Surgical Quality Improvement Program (NSQIP), comparing performance metrics with other centres does not occur within our system. However, we have used contemporary complication rates generated from large randomised controlled trials to benchmark our performance.[9] An advantage of the ERD relative to NSQIP is that the ERD provides reporting of all index procedures rather than sampling. We believe complete reporting will identify infrequent complications more reliably.

A further limitation of the ERD is the failure to report adverse events following rarely performed operative procedures. The impact of this limitation appears to be small. Rarely performed operative procedures are not usually the focus of quality improvement initiatives. The ERD display selection

can also be modified to capture adverse events from new operative procedures as deemed appropriate by the clinical team.

Another limitation is the capture of adverse events in readmissions that required additional linkages within the data warehouse. Once this deficiency was identified within our system, the correction was straightforward as the reporting system was held within the electronic health record. This facilitated linkages to other data sources that allowed documentation of readmission. This correction was depicted with the improvement in sensitivity, specificity and kappa statistic in the 1-year follow-up period.

Additionally, the usefulness of this reporting system is unknown in clinical fields, such as medical services (ie, non-surgical care settings) where patients do not always have a definable major clinical event, like a major surgical procedure. The ability to construct an ERD system with other electronic health record vendors is also not known.

CONCLUSION

We found that an electronic discharge summary with structured embedded data fields linked to an automatic web-based reporting system can provide accurate real time data of thoracic surgical adverse events. The use of an electronic discharge summary with structured embedded data fields linked to an adverse event reporting system addressed a number of limitations of previous reporting methodologies. We believe our methodology provides an alternative system for surgical clinical teams to consider when developing adverse event reporting systems.

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