Patterns of first-coded complications in acute episodes of lung cancer care

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Abstract

The objective of this research was to document the most common first-recorded adverse events of inpatient care for lung cancer in Victoria, Australia. The sample comprised record abstracts for 3642 admissions (overnight or longer) of adult patients with lung cancer, extracted from the Victorian Admitted Episodes Database for 2000-2001. The method involved analysis of diagnoses prefixed with 'C' (an indicator for diagnoses which arose only after hospitalisation), calculation of complication rates by intervention type, and analysis of complication type by intervention. Overall, 23% of episodes recorded at least one in-hospital complication, with highest rates for radiotherapy and surgical interventions. The highest surgical complication rates were for pneumonectomies, lobectomies, and lung resections. Nausea and vomiting were the most common first-recorded complications for both chemotherapy and radiotherapy. It was concluded that complications through the use of morbidity data may offer a timely and economical method for health care organisations to screen large numbers of patient episodes.

Keywords (MeSH):

Lung cancer; administrative data; complications; adverse effects; cancer therapy

Introduction

Lung cancer is a major public health burden and remains the leading cause of cancer related mortality in Australia (Australian Institute of Health & Welfare and Australasian Institute of Cancer Registries 2004). A range of therapies are used separately and in combination to improve the possibility of cure or increase the likelihood of remission. As lung cancer is often diagnosed late, much of the therapeutic intervention is palliative. Thus patients are faced with not only a life-limiting illness with a poor prognosis, but also the adverse effects of treatments which may provoke more fear and dread in sufferers than the disease itself. For this reason, there is a need to understand more about the prevalence of common adverse events and complications of treatment, in order to develop quality care interventions for these patients. This paper demonstrates an alternative approach to identifying adverse events through the use of morbidity data extracted from the Victorian Admitted Episodes Database for 2000-2001.

Identifying adverse events and complications of care

Lung cancer has emerged globally as a serious health threat. Since the mid eighties it has had the highest mortality rate of all cancers, in addition to being the most common cancer worldwide (Parkin et al. 2005). In Australia the situation is similar, with lung cancer responsible for 20.1% of cancer related deaths in addition to having one of the lowest relative survival rates of all cancers in males and females (Australian Institute of Health & Welfare and Australasian Institute of Cancer Registries 2001). For the five-year time period between 1992-1997, relative survival rates were 11.0% for males and 14.0% for females (Australian Institute of Health & Welfare and Australasian Institute of Cancer Registries, 2001). In fact, survival rates have changed little over the last four decades (Pearson 1999).

Around 2,000 new cases of lung cancer are diagnosed in Victoria each year, with males outnumbering females in the ratio 1.85:1. Researchers attribute this gender difference to

historical and cultural factors influencing the prevalence of tobacco smoking in the population (Giles & Thursfield 2002). Although a number of environmental and genetic factors are implicated in the development of lung cancer, a number of studies have established clear evidence that tobacco smoking is the main agent responsible for the majority of lung cancers (Parkin et al. 1994; Ridolfo & Stevenson 2001; Vineis et al. 2004).

Lung cancer is a debilitating disease and interventions such as surgery, radiotherapy and chemotherapy are themselves debilitating. In such vulnerable patients, even minor complications can be life threatening and compromise quality of life. It is important, therefore, to document common complications acquired during treatment and to focus efforts to improve patient safety and quality of care. Much of what we do know of adverse events in hospitalised patients, is as a result of studies based on record review (Leape et al. 1991; Wilson et al. 1995). Although considered the 'gold standard', record review is a method too expensive and time consuming to be easily used for monitoring complications and adverse events.

This study demonstrates the use of an alternative method, using coded administrative data routinely collected by hospitals and submitted to State health departments, as a tool to identify common adverse events found in lung cancer episodes of care. Coded data from administrative databases have previously been used to describe cancer incidence and prevalence, and in monitoring quality of care outcomes (Barzilai et al. 2004). As such, they provide an alternative method to record review that is timely and relatively low cost.

Data and methods

The study sample consisted of a subset of inpatient record abstracts drawn from the Victorian Admitted Episodes Database (VAED) for the period 1 July 2000 – 30 June 2001. These data represent admitted multi-day episodes of care of patients over 18 years of age with a principal diagnosis of lung cancer. The principal diagnosis is defined as: The diagnosis established after study to be chiefly responsible for occasioning the patient's episode of care in hospital (National Centre for Classification in Health 2000a). Records for lung cancer patients admitted for treatment of other conditions are thus not included in this sample.

Same day cases were excluded on the basis of a previous study (Jackson et al. 2006) that found a significantly lower rate of complications in same day episodes (0.4%), compared to multi day episodes (11.5%). Complications of care for same day patients are typically diagnosed only after discharge from hospital, and thus analysis of incident cases would under-count these complications. As 20% of the cases in the sample were identified as same day, there was concern the lower rate of complications from such a large number of cases would bias the study findings. The final study sample size was n = 3642 records.

Males accounted for 61% of episodes and females 39%. The highest frequencies of episodes were for persons in the 70-74 year age group. These represented 22% of all episodes.

Incident complications were identified through the use of a prefix, which is attached to each diagnosis code by trained coders at the time of record abstraction. In Victoria, there are a number of State additions to the National Coding Standards (National Centre for Classification in Health 2000a). One important addition governs the mandatory assignment of prefixes to each diagnosis code (Victorian Department of Human Services 2000). The prefixes used are: P- Primary, A- Associated or M- Morphology (used with neoplasm coding) and C- Complication.

Through the use of these prefixes, any diagnosis can be distinguished as pre-existing (i.e. present at the time of admission: P, A or M) or classed as a new condition acquired while in hospital (C). The 'C' prefix denotes any new condition that was not present on admission and which required additional treatment or extended length of stay. This corresponds closely to the definition of 'adverse event' recommended by the Australian Council on Safety and Quality in Health Care: 'An incident in which unintended harm resulted to a person receiving health care' (Australian Council on Safety and Quality in Health Care 2005). In this paper we use the terms 'adverse event' and 'complication' interchangeably. While we are not able to distinguish causative 'incidents' from the data, the analysis

clearly shows that complications are related to patterns of patient care.

In addition to the 'C' prefix, a group of ICD-10-AM codes are designed explicitly to capture complications of care. These codes occur in the range [T80 – T88.9], or if the complication is considered medically important in its own right, may occur at the end of relevant 'chapters' (body-system divisions of ICD-10-AM) and are therefore referred to as 'End of Chapter codes'.

Coding standards also specify that the injury codes must identify the cause of the event or injury and the place where the event or injury occurred. These are called 'external cause codes' and are sequenced after complication codes in the range [Y40-Y84.9] (National Centre for Classification in Health 2000b).

For this analysis, only the first recorded C-prefixed code on each abstract is analysed, although up to 24 fields may be used for recording complications of care and other additional diagnoses. Thus, incidence measures reported here relate only to episodes, and not to the incidence of individual complications. Analysis of multiple codes on records would require consideration of complex patterns of coding which arise from multiple codes which are required for coding external causes of injury.

Grouping of procedures and intervention codes

A frequency table was generated for the principal procedure field in each record. Each procedure or intervention was grouped into one of eight major categories: Medical, Minor surgical, Surgical, Chemotherapy, Radiotherapy, Scans and Imaging procedures, Allied Health, and Other miscellaneous procedures.

Operative procedures were grouped according to the type and intensity of the intervention: Pneumonectomy, Lobectomy, Lung resections, Other lung procedures, and Non-lung procedures. A full report of code assignment is available from the authors.

Grouping of complication codes

The first recorded 'C' prefixed diagnosis on each record was used to generate a frequency table identifying the number and type of complications found. Each complication code was then grouped into one of 15 major categories (shown in Table 4 below).

The categories were generally based on body system, apart from procedural/post procedural complications, metabolic imbalances, signs and symptoms, and those complications numerous and severe enough to be distinguished in their own right. These included infection/sepsis, cellulitis/decubitus ulcers, pneumonia, and drug complications.

Results

Table 1 summarises the major findings of the study, with Table 2 providing a breakdown of complication rate by intervention modality, and Tables 3 and 4 showing details of complication categories by intervention modality and type.

Table 1: Results summary

- The mean complication rate for the sample was 23%.
- Records with an intervention accounted for 83% of episodes, with surgical procedures accounting for 32% of all episodes, chemotherapy 19%, and allied health interventions 15%, radiotherapy 8%, scans and imaging 7%, and transfusions 3%.
- Seventeen per cent of episodes had no procedure or intervention recorded.
- Radiotherapy recorded the highest overall complication rate (36%), followed by surgical procedures (34%).
- Higher complication rates were associated with more invasive surgical procedures: pneumonectomies 62%, lobectomies 51%, and lung resections 51%.
- The most common complications for both radiotherapy and chemotherapy were nausea and vomiting. Oesophagitis and candidal stomatitis were also frequently found in radiotherapy episodes.

Complication rates by treatment modalities

Radiotherapy

Table 2 shows radiotherapy episodes had the highest complication rate at 36%, with only 8% of the sample receiving this treatment modality. Data in Table 4 indicate 26% of radiotherapy episodes had a complication in the signs and symptoms category. Nausea and vomiting was the

most common of these, accounting for 16% of radiotherapy complications. This was followed by disorientation and fever in 6% of episodes.

Table 2: Treatment modality by percent of episodes and by rate of any complication

INTERVENTION TYPE	% OF EPISODES *	% ANY COMPLICATION
Radiotherapy	8	36
Surgical procedures	32	34
Allied health interventions	15	25
Transfusions	3	18
Scans and imaging	7	14
Chemotherapy	19	12
No procedure	17	10
Total episodes	**100**	**23**

* Percentages rounded

Digestive system complications were recorded in 19% of radiotherapy episodes. Of these, oesophagitis and candidal stomatitis were the most frequent. Radiotherapy episodes had a significantly higher rate of oesophagitis or candidal stomatitis than other treatment episodes ($\chi^2 = 120.399$; $p<0.000$).

Pneumonia was the most commonly recorded respiratory system complication associated with radiotherapy episodes, followed by respiratory distress/collapse. These accounted for 8% and 5% of radiotherapy complications respectively.

Surgical complications

Surgical interventions were the most frequent amongst these admitted patients (32% of episodes), and also showed one of the highest rates of complications, at 34% of surgery cases.

Of the surgical episodes with complications, 31% had a procedural or post procedural complication. Procedural/post-procedural adverse event codes specifically indicate 'a condition or injury, which is related to a surgical/procedural intervention rather than the patient's disease process' (National Centre for Classification in Health 2000a: p. 217). The procedural/post-procedural complications were predominantly respiratory disorders (13% of all surgical episodes), subcutaneous emphysema (5%), haemorrhage and laceration (3%), and post-procedural infection (3%).

Other common complications in the surgical category included circulatory system disorders (19%), and respiratory system disorders (11%) (Table 4). Non-procedural complications (e.g. respiratory, infection/sepsis) are assigned a different code to those in the procedural/post-procedural category, to indicate that documentation did not exist to link the complication directly to the intervention, or when it clearly arose as a result of the patient's disease process.

Complications by specific surgical procedure

Table 3 shows that the rate of complications is related to the invasiveness of the surgical procedure, and that procedural/post-procedural and circulatory complications are the most common first-recorded complications.

Pneumonectomy

Pneumonectomy is a major surgical procedure that entails the removal of a whole lung. The 62% complication rate reflects the invasive nature of the procedure.

Procedural/post-procedural adverse events accounted for 38% of all pneumonectomy complications. Two complication types predominated: haemorrhage or laceration (14% of all pneumonectomy complications), and subcutaneous emphysema (another 14%).

Forty-three percent of pneumonectomy complications were related to the circulatory system, and the largest sub-group of these were arrhythmias (24% of all pneumonectomy complications).

Lung resections

Lung resections are less invasive than pneumonectomies and involve surgically excising part of the lung. More than half of the resection episodes entailed an adverse event, and over 40% of these were procedural/post-procedural. The largest sub-groups were post-operative respiratory system disorders (15% of resection procedural complications) and acquired subcutaneous emphysema (7%). Other complications included anaemia and urinary retention (7% of complicated resection episodes, respectively), and pneumothorax and cardiac arrhythmias (6% of complicated resection episodes, respectively).

Lobectomies

Lobectomies are the least invasive of the lung procedures and involve removal of part of the lung. Adverse events were recorded in more than 50% of lobectomy episodes, and procedural/post-

procedural respiratory sub-category disorders were again the most common, accounting for 14% of adverse events. Cardiac arrhythmias made up another 13% of lobectomy complications, and 'other' circulatory system disorders, a further 7%.

Biopsies

Forty-three per cent of biopsy complications were in the procedural/post-procedural category and, of these, respiratory disorders were the most common and accounted for 33% of complicated episodes. A further 7% of biopsy adverse events were pneumothorax.

Chemotherapy

The recorded complication rate for chemotherapy episodes was 12% (Table 2). This was the second lowest complication rate in comparison to other interventions, but may be underestimated for short episodes where symptoms develop only after discharge and would thus be unrecorded.

Table 4 shows 26% of chemotherapy episodes with a recorded complication were assigned to the signs and symptoms category. Within this category, the most common first-recorded complications were nausea and vomiting (12% of chemotherapy complications) and skin complications (5%).

Results also indicated circulatory system complications, metabolic complications, and psychological disorders were recorded in 14%, 11% and 7% of chemotherapy episodes with a complication, respectively.

Allied Health interventions

Allied health interventions were associated with a complication rate of 25% (Table 2), although most complications would be related to interaction between patient condition and the medical care provided in the episode, rather than to the allied health intervention itself. In these episodes, no curative or therapeutic interventions such as surgery, chemotherapy or radiotherapy were undertaken. Coding standards mandate a hierarchical sequencing of procedure codes, with coding of allied health interventions only after more invasive modalities have been coded. Had there been surgery or radiotherapy in this group of episodes, they would have been coded as the principal procedure before the allied health intervention code.

The data in Table 4 show 16% of allied health episodes with complications had a digestive system disorder as the first C-prefixed complication, followed by the circulatory system (15%) and the respiratory system (13%). Eleven per cent of complications in patients receiving only allied health interventions were in the signs and symptoms category.

Scans and Imaging

Table 4 shows that 21% of first-recorded complications in these episodes involved the circulatory system, followed by 18% in the signs and symptoms category. Table 2 shows the relatively low overall complication rate in this category of 14%.

Transfusions

All transfusion procedures were for blood products. Only 19 episodes of the total 108 episodes for transfusions were recorded with a complication (17.6%). Of these, blood disorders, circulatory system complications, and disorders in the signs and symptoms category accounted for 16% of episodes for each category respectively.

Episodes without an intervention or procedure

In episodes where no procedure or intervention was recorded, the overall complication rate was a relatively low 10% (Table 2). In these episodes digestive system disorders, followed by hospital-acquired pneumonia and urinary system disorders, accounted for 18%, 16% and 13% of first-recorded complications respectively.

Discussion

Lung cancer represents an important area of morbidity and mortality, and continued efforts must be made to reduce the occurrence of preventable complications to improve quality of life for patients. Although a number of studies have attempted to ascertain the frequency of complications associated with lung cancer treatment, few have focussed on identifying adverse events of cancer treatment from administrative databases. Instead these have been used to evaluate outcomes of lung cancer surgery (Romano et al. 2002; Romano & Mark, 1992; Whittle et al. 1991).

Early research into the use of administrative data to screen for preventable complications of

Table 3: Surgical Principal Procedures

	SURGICAL PRINCIPAL PROCEDURES			
COMPLICATION TYPES	PNEUMONECTOMY	LUNG RESECTIONS	LOBECTOMY	BIOPSIES
Procedural/Post procedural cc's	38.1%	40.7%	35.1%	43.1%
Prosthetic cc's	0.0%	3.7%	2.7%	3.4%
Haemorrhage/Laceration CC's	14.3%	1.9%	1.8%	3.4%
Post procedural respiratory cc's	4.8%	14.8%	13.5%	32.8%
Post procedural circulatory cc's	0.0%	5.6%	5.4%	0.0%
Post procedural cc's to other sites	0.0%	1.9%	0.0%	0.0%
Other post procedural cc's	0.0%	1.9%	2.7%	0.0%
Post procedural infection	4.8%	3.7%	3.6%	1.7%
Post procedural subcutaneous emphysema	14.3%	7.4%	5.4%	1.7%
Circulatory system cc's	42.9%	11.1%	21.6%	6.9%
Acute myocardial infarction	4.8%	1.9%	0.0%	1.7%
Angina	0.0%	0.0%	0.9%	0.0%
Arrhythmias	23.8%	5.6%	12.6%	1.7%
Cardiac failure	0.0%	1.9%	0.0%	0.0%
Embolism	0.0%	0.0%	0.9%	0.0%
Other circulatory cc's	14.3%	1.9%	7.2%	3.4%
Respiratory system cc's	4.8%	11.1%	11.7%	17.2%
Pneumothorax	0.0%	5.6%	1.8%	6.9%
Respiratory distress/collapse	0.0%	1.9%	2.7%	5.2%
Dyspnoea	4.8%	0.0%	0.0%	0.0%
COAD/Emphysema	0.0%	0.0%	0.9%	0.0%
Other respiratory cc's	0.0%	1.9%	5.4%	3.4%
Signs & Symptoms	4.8%	1.9%	9.0%	5.2%
Urinary system cc's	4.8%	11.1%	6.3%	5.2%
Retention	0.0%	7.4%	2.7%	0.0%
UTI	4.8%	0.0%	1.8%	3.4%
Other urinary system cc's	0.0%	3.7%	1.8%	1.7%
Metabolic cc's	4.8%	1.9%	4.5%	5.2%
Digestive system cc's	0.0%	7.4%	1.8%	10.3%
Blood cc's	0.0%	7.4%	1.8%	0.0%
Anaemia	0.0%	7.4%	0.9%	0.0%
Thrombocytopenia/Coagulation defect	0.0%	0.0%	0.9%	0.0%
Psychological cc's	0.0%	3.7%	1.8%	1.7%
Pneumonia	0.0%	1.9%	0.9%	1.7%
Falls & Injuries	0.0%	0.0%	0.9%	1.7%
All other complications	0.0%	1.9%	3.6%	1.7%
	100.0%	100.0%	100.0%	100.0%
Percent of episodes with any complication	61.8%	51.4%	51.4%	33.1%

care relied on particular ICD-9-CM (International Classification and Diseases 9th revision, Clinical Modification) codes that specifically identified adverse events. Confounding the researcher's work, however, was an inability to distinguish, clearly, complications from co-morbidities (Iezzoni et al. 1994). This limitation was especially apparent with identifying medical complications arising after the episode of care commenced, and determining whether such a condition actually arose as a result of the hospitalisation (Lawthers et al., 2000).

Few studies have been able to distinguish separately complications arising after the hospitalisation from co-morbidities. Two early studies (Naessens et al. 1991; Roos, Stranc, James & Li, 1997) used an indicator variable to distinguish whether the complication occurred after the patient's admission or was in fact present on

admission. The study outcomes, however, were not to assess rates of complications, but to assess relative risk.

In Victoria, the use of a prefix attached to the diagnosis code allows the researcher to distinguish additional diagnoses that occur after the patient's admission from coexisting conditions the patient had at the time of admission. Jackson et al. (2006) used the Victorian Admitted Episodes Database from 2000-2001 to compare rates of adverse events using the Victorian C-prefix compared with use of International Classification of Diseases and Related Health Interventions, 10th revision, Australian Modification (ICD-10-AM) diagnosis codes alone.

The overall rate of complications found in this study was 8.25%, similar to those reported from record review. Using ICD-10-AM codes alone, however, researchers found a rate of 4.85%.

O'Hara and Carson's (1997) study attempted to identify complications from diagnosis codes alone, and found a similar complication rate of 5%. Part of this study was replicated using the Alfred Hospital's morbidity data, and researchers demonstrated the value of using the data for monitoring a range of adverse events and as an indicator to estimate the frequency of adverse events (Carroll, Mclean & Walsh 2003).

In this study we aimed to explore the type of common complications recorded in routine medical record abstracts for various treatment modalities in lung cancer inpatient care, and to compare these with the clinical literature on such complications.

Radiotherapy

Radiotherapy is the most common treatment modality in lung cancer (Price 2003), used to control the spread of disease or to provide palliation. As is also true for chemotherapy, consideration must be given to the effects of the therapy on healthy tissue as adverse effects are dependent on factors such as the size of the area to be treated and the proximity to vital organs (DeLaney 2002).

The severity of nausea and vomiting in radiotherapy treatment are related to the total radiation; for example almost 100% of patients undergoing total body irradiation will experience these symptoms compared to 10 - 30% who only have radiation of the cranium (Schnell, 2003).

Table 4: Patterns of complication type by treatment modality (principal procedure)

	TREATMENT MODALITY								
CATEGORY	RADIO-THERAPY	SURGERY	CHEMO-THERAPY	SCANS & IMAGING	ALLIED HEALTH	TRANSFUSIONS	OTHER	NO PROCEDURE	% OF 1ST RECORDED COMPLICATIONS
Procedural/Post procedural	1.0	30.9	2.5	---	3.7	1.6	50.0	---	15.8
Circulatory system	9.5	19.4	13.8	20.6	14.9	15.8	---	11.3	16.2
Digestive system	19.0	4.8	7.5	11.8	15.7	5.3	50.0	17.7	10.0
Respiratory system	11.4	11.5	7.5	8.8	12.7	10.5	---	11.3	11.1
Pneumonia	7.6	1.8	1.3	5.9	4.5	---	---	16.1	4.1
Signs & Symptoms	25.7	9.2	26.3	17.6	11.2	15.8	---	9.7	13.8
Injuries & Falls	2.9	1.5	1.3	5.9	5.2	---	---	3.2	2.5
Metabolic	4.8	5.4	11.3	8.8	4.5	5.3	---	---	5.4
Urinary system	4.8	5.9	3.8	8.8	8.2	5.3	---	12.9	6.5
Blood	5.7	2.3	2.5	---	1.5	15.8	---	1.6	2.8
Psychological	1.0	2.3	7.5	---	2.2	10.5	---	1.6	2.7
Cellulitis/Decubitus ulcers	---	1.0	5.0	2.9	4.5	5.3	---	1.6	2.1
Infection/Sepsis	1.0	1.3	3.8	2.9	0.7	---	---	---	1.3
Adverse effects of drugs	1.0	0.8	---	---	3.0	5.3	---	---	1.1
Other	4.8	2.0	6.3	5.9	7.5	5.3	---	11.3	4.6
Total	100	100	100	100	100	100	100	100	100
Total count	105	392	80	34	134	19	2	62	828

In the current study, nausea/vomiting and stomatitis/oesophagitis, were identified as the leading types of complications of radiotherapy episodes, consistent with the literature. Oesophagitis generally occurs two – three weeks after treatment begins, although toxicity to the oesophagus may occur sooner if concurrent chemotherapy is being administered (Knopp 1997; Price 2003) as this treatment sensitises the tissues to radiation (Yeh et al. 2004). Our study found radiotherapy episodes had a significantly higher rate of oesophagitis or candidal stomatitis than other treatment episodes ($\chi^2 = 120.399$; $p<0.000$).

Fatigue is also commonly reported in the literature, with nearly all patients experiencing this to some degree, regardless of the size of the treatment area (Armes, Krishnasamy & Higginson 2004; Sitton 1997). We found no recorded episodes of fatigue common to both radiotherapy and chemotherapy. This is likely to be due to the condition already being present when the episode commenced and hence not flagged as a 'new' complication, or becoming apparent only after discharge. The high rate of complications in radiotherapy can be explained if we consider that it has a major role in palliation (Haas 2003).

Pulmonary complications such as radiation pneumonitis can be difficult to diagnose clinically, masking the true incidence (Monson et al., 1998). Symptoms such as dyspnea with new or worsening cough or fever are indicators of radiation pneumonitis, with manifestation of symptoms occurring one to three months after completion of therapy (Knopp, 1997). In lung carcinoma patients the incidence varies, and this may be attributed to difficulty in obtaining a definitive clinical diagnosis as dyspnea and fever may develop from a variety of causes (Monson 1998). Our study found no record of radiation pneumonitis, as these late complications would not be recorded in acute episodes, unless the patient was hospitalised for a long enough period for them to become apparent before discharge.

Lung cancer surgery

For those patients undergoing lung cancer surgery, there is agreement in the literature that the majority of complications reported are respiratory and cardiovascular (Licker et al. 2002; Nagasaki, Flehinger & Martini 1982; Stephan et al. 2000; Uramoto et al. 2001); however, post operative complication rates overall show great variation. Nagasaki et al. (1982) found a complication rate of 19%, while Licker et al. (2002) reported a complication rate of 47%. These variations have been attributed to differences in defining the type of complication studied and differences in the functional status of the patient (Stephen 2000). Additionally the burden of coexisting diseases in each patient impacts on their ability to better tolerate invasive procedures; selection criteria therefore will also influence overall complication and survival rates (Pearson 1999).

Our study found an incident complication rate for lung surgery of 34%, well within the range found in other studies. Similarly, we found that the largest group of post-operative surgical complications were cardio-respiratory in nature. We also found that procedural and post-procedural complications represent nearly a third of surgical adverse events, many with cardiac or respiratory consequences.

As would be expected, we found that the rate of adverse events varies with the extent of surgery, more invasive procedures such as pneumonectomy incurring the highest complication rate. We did not investigate the burden of coexisting disease in these episodes.

Chemotherapy

Chemotherapy also is an important treatment modality for lung cancer, and research is continuing to explore new drug regimes (often combined with radiotherapy) in an effort to improve the outcome of those with the disease (DeLaney 2002; Rathore & Weitberg 2002).

Chemotherapies target rapidly dividing cells and these include the bone marrow, gastrointestinal mucosa and hair follicles, decreasing the body's ability to replace cells that have died (Wilkes 1996). Interference with the normal production of these cells therefore may lead to severe complications from infection, haemorrhage, anaemia, and fatigue (Wilkes 1996). Our study found only one episode each for anaemia and neutropenia in the chemotherapy group. Given that three per cent of all episodes in the sample were for blood transfusions, it is likely

that these complications were already present when the patient was admitted. Our focus on incident (rather than pre-existing) complications would not have identified those present on admission.

Adverse effects of treatment may also be seen on all organs susceptible to the particular drug being used, as chemotherapy does not distinguish between healthy cells and malignant cells (Walker 2003). These include cardiovascular complications, metabolic imbalances due to chemical destruction of the tumour cells (Yeh et al. 2004), and symptomatic type complications such as nausea and vomiting. Our study found cardiovascular conditions, nausea/vomiting, and metabolic conditions to be the most frequent complications for these inpatient chemotherapy episodes, consistent with the expected pattern of chemotherapy complications.

Differences in the types of complications found in radiotherapy and chemotherapy episodes can be explained by factors governing the coding process. We extracted only the first 'C-prefixed' code on the record. However, it is likely that there is more than one complication code (or sequence of codes) on most records, and different patterns might emerge if all codes were considered.

A second explanation is that there is no coding standard guiding the sequencing of complications, although clinical coders are directed to sequence the more significant ones higher in the string. However, given the wide range of symptomatic type complications common in chemotherapy, choosing the most significant may be problematic for coders.

Other intervention types

The relatively high rate of complications for episodes with allied health as the principal procedure may reflect the palliative nature of these admissions, with patients at a later stage of the disease. Diagnostic interventions such as scanning and imaging are likely to occur earlier in the disease process, and are associated with much lower rates of complications.

Methodological limitations and strengths of the research

Much of chemotherapy and radiotherapy is provided on a day-case or outpatient basis. Because of the short follow-up available for coding complications, these two groups were excluded from our study; therefore the frequency and type of complications commonly found in these episodes remain unknown.

In addition, our study only extracted the first complication code in the record. While the number of episodes reporting any complication is reliably identified by this method, the overall frequency of different complication types is not known and hence rates for particular complications may be under-reported.

Other issues that may affect the validity of the data include poor documentation in the medical record, incomplete abstraction from the medical record, or organisational factors that limit coding to those conditions that affect diagnosis related group (DRG) assignment. Considerable variation exists in coding depth by hospitals (Jackson et al. 2006) and this would impact on the number of complications that are recorded. Finally, we do not know severity or stage of disease in our sample, characteristics that may also influence the rate of complications in the various groups.

However, the strengths of this study and others using incidence-flagged data lie in their value as a screening tool. Currently, no method exists for hospitals to screen routinely for new complications acquired within the episode of care, and for which the care team should accept responsibility. Record review, considered the 'gold standard', is too time consuming and expensive and therefore not amenable to screening large numbers of records in a timely way to assist in quality assurance programmes. Additionally, the data reflect population-based characteristics and are therefore not subject to selection bias inherent in some prospective studies.

Conclusions

Identifying common complications in cancer therapies is essential to improving quality of care and reducing adverse effects of such therapies. Screening of morbidity data may offer a timely, economical method for health care organisations to review large numbers of records and use comparative rates of complications to target their quality assurance efforts.

Further improvements in coding standards to guide code assignment and sequencing will

improve the validity of the data. Additional diagnoses, such as those analysed here, are a desirable component to enrich the database for research. The Victorian Department of Human Services has recently increased the number of diagnosis fields to 40 per abstract, and this increase in the number of available coding fields will also improve the quality of the data.

Ongoing monitoring of complications and adverse events is an essential component of high quality cancer care. Readily available and good quality data may provide the means to ensure health care organisations are able to incorporate such improvement strategies into their frameworks to ensure the well being of patients already burdened with debilitating illness.

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