ORIGINAL ARTICLE

Misinterpretation of the chest x ray as a factor in the delayed diagnosis of lung cancer

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Postgrad Med J 2002;**78**:158–160

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Submitted 25 July 2001
Accepted
19 October 2001

Lung cancer is the commonest cause of cancer related death in the UK and has five year survival rates lower than in most European countries.¹ The reasons for these poor figures are complex, but are likely to be due, at least in part, to the frequent presentation of patients with late stage disease and the presence of comorbidities that preclude surgery. Although the possibility of screening for lung cancer is currently being examined in a variety of studies, most patients are symptomatic at diagnosis² and initial investigation will be chest radiography. Following our experience of several cases of lung cancer in patients where a retrospective review of x rays revealed an unrecognised abnormality, we decided to audit a group of patients in whom the diagnosis of lung cancer had been made. A cohort of patients who had presented to the chest unit over a fixed time period were selected and previous radiological investigations were reviewed to ascertain whether there had been any diagnostic delay.

PATIENTS AND METHODS

Cases

One hundred patients with a histologically proved diagnosis of lung cancer were identified retrospectively from pathology records in Castle Hill Hospital between 1 January and 31 December 1997. Twenty were tertiary referrals from outside the district and were excluded on the basis that we would be unable to access all previous radiological investigations. In 22 patients a full set of medical records or x rays could not be retrieved, therefore 58 patients were studied. Each set of medical records was examined to establish patient demographics, date of diagnosis of lung cancer, indication for diagnostic chest x rays, date and modality of any treatment given, and date of death. Histological cell type was obtained from pathology records.

Review of chest x rays

The "diagnostic" chest x ray (defined as the chest x ray on which an abnormality was correctly identified and acted upon) was identified by one researcher (PMT) after review of

All patients in 1997 with a histologically proved diagnosis of lung cancer in Castle Hill Hospital in whom a full set of case notes and x rays could be retrieved were studied. All previous chest x rays were reviewed by a consultant chest physician and a radiologist, who were blinded to the eventual site of the lesion and the point at which a suspicious abnormality first appeared. Case notes were inspected to clarify the cause of any error. Fifty eight patients were eligible, 28 of whom had previous chest x rays. Of these 14 were found to be abnormal. A significant difference ($p=0.007$) in time from diagnosis to death was found between those with a missed abnormality, median (interquartile range, IQR) 105 (55–219) days and those with no previous abnormality, median (IQR) 260 (137–512) days. In the 14 in whom the diagnosis was missed the median (IQR) delay from first abnormal chest x ray to the eventual diagnostic x ray was 101 (48–339) days. A significant difference ($p=0.001$) was also found between the median (IQR) time from first abnormal chest x ray to start of treatment between those with missed abnormalities, 155 (115–376) days, and those with no previous abnormality on chest x ray, 51 (44–77) days. The most common reason (47%) for the diagnosis to be missed was failure of the radiologist reporting the x ray to recognise the abnormality.

It is not unusual to find previous significant radiological abnormalities in patients in whom a diagnosis of lung cancer is later made. This leads to a diagnostic delay which has a significant effect on time to initiation of treatment and palliation of symptoms, although not necessarily to eventual outcome.

all available chest x rays. All chest x rays up to five years before the "diagnostic" chest x ray were then reported by a consultant chest physician and radiologist who were blinded to the site of the subsequently identified abnormality, the dates of all previous x rays and the date at which a definite abnormality first appeared. Disagreement between observers was resolved by discussion. When a missed abnormality was identified the medical records and radiology reports were re-examined to establish the cause of the error. The position of the missed abnormality on the chest x ray was recorded. Neither of the two index cases was included in the study.

Errors were categorised into five predetermined groups:

- (1) Tumour not recognised by radiologist or physician.
- (2) Physician disagreeing with radiologist report suggesting tumour.
- (3) Accurate report issued by radiologist but not seen or acted upon by physician.
- (4) Unhelpful or ambiguous report issued by radiologist.
- (5) Follow up suggested on report but not carried out by physician.

Analysis of data

Statistical analysis of all data was performed with SPSS version 9.0 for Windows. Parametric data are described as mean and standard deviation. Survival data did not approximate to a normal distribution and therefore are described as median and interquartile range. Statistical comparisons were made using Student's *t* tests for parametric data and χ^2 tests for non-parametric data. Differences in survival and time to treatment between patients with missed abnormalities and those with no previous abnormal chest x ray were assessed using Kaplan-Meier survival analysis. A *p* value of less than 0.05 was considered to indicate statistical significance.

RESULTS

A total of 58 patients were studied. The mean (SD) age of the group was 70.68 (7.6) years, with 62% of the group being

Figure 1 Bar chart of errors made in diagnosis.

male. The majority (72%) of the “diagnostic” chest x rays were performed as part of investigation for primary chest symptoms (for example, cough or breathlessness), with 21% requested due to a more generalised indication (for example, weight loss) and 7% were requested routinely, usually as part of a preoperative screen.

Fourteen (24%) patients were found to have a pre-existing chest x ray abnormality. A total of 19 errors were identified in these 14 patients. One patient had an unrecognised abnormality on two occasions and two had an unrecognised abnormality on three occasions. The most common reason for diagnosis of lung cancer being missed on a previous chest x ray was a failure of the radiologist reporting the x ray or the physician who requested the x ray to recognise that it was abnormal. Figure 1 shows a breakdown of the errors into the five predetermined categories.

Hilar lesions were the most commonly unrecognised abnormalities, with left hilar masses missed on seven occasions, and right hilar masses missed twice. Rounded opacities were unrecognised on five occasions, with three being in the right upper lobe, one in the left upper lobe, and one in the right lower lobe. Lobar collapse was also missed on five occasions, with right lower lobe collapse unrecognised four times (on three occasions in a single patient) and right upper lobe collapse unrecognised once.

There were no significant differences between the patients who had a correctly interpreted abnormality and those with a missed chest x ray abnormality in terms of age (71.1 v 64.6, $p>0.05$) and sex (61% v 64%, $p>0.05$). The absolute numbers and relative proportions of patients with each cell type were as follows: squamous cell 14 (24%), adenocarcinoma 11 (19%), undifferentiated non-small cell 11 (19%), small cell 18 (31%), and unknown four (7%). The relative proportions of small cell and non-small cell carcinoma are typical for any lung cancer population. There was no significant difference in the frequency of small cell carcinoma between patients with no previous abnormality and those with a missed abnormality on chest x ray (29.5% v 28.5%, $p>0.05$).

The median (interquartile range, IQR) survival of all patients from diagnostic chest x ray was 214 (96–348) days. Seven patients were still alive at the end of 1998, none of whom were found to have a pre-existing chest x ray abnormality. A significant difference between median (IQR) survival of those with no previously abnormal chest x ray, 260 (137–512) days and those with a pre-existing abnormality 105 (55–219) days from diagnostic chest x ray was found ($p=0.007$). Figure 2 shows the Kaplan-Meier survival curve for survival from diagnostic chest x ray. However no significant

Figure 2 Kaplan-Meier plot of survival in days from diagnostic chest x ray. A significant difference is seen between the two groups.

Figure 3 Kaplan-Meier plot of survival in days from first abnormal chest x ray. No significant difference is seen between the two groups.

difference was found between the median survival in two groups from first abnormal chest x ray (260 v 228 days, $p=0.7$). Figure 3 shows the Kaplan-Meier survival curve from first abnormal chest x ray in the two groups.

A significant difference ($p=0.001$) was also found between the median (IQR) time from first abnormal chest x ray to start of treatment between those with a pre-existing chest x ray abnormality, 155 (115–376) days and those with no previously abnormal chest x ray, 51 (44–77) days. A total of 10 (17%) patients had surgery as treatment of their lung cancer. Of those who had no previous abnormalities four (29%) underwent surgery, compared with only two (14%) of those who had a pre-existing abnormality ($p=0.008$). No patient with pre-existing abnormalities was alive one year after surgery. No patient received radical radiotherapy.

DISCUSSION

It is axiomatic that most curative treatments in lung cancer are surgical and that successful surgery depends on diagnosis of patients at an early stage.³ Although a body of in vitro research now suggests micrometastases occur early in the natural history of all types of lung cancer,^{4–8} it is usually assumed that patients presenting with inoperable tumours have migrated through a stage where their disease might have been curable or at least had a chance of prolonged survival.³ Our results have shown that the opportunity for an earlier diagnosis was lost in a

considerable proportion of cases. As staging information was not available for patients at the time of their initial "missed" x ray we could not compare their disease stage (and by inference prognosis) at that time with their stage at the time of eventual diagnosis or in the group where no diagnostic delay had been incurred. Although survival from diagnosis was greater in the group of patients who had correctly interpreted chest x rays, we suspect that this represents the phenomenon of lead time bias as survival from first abnormality (whether recognised or not) to death was not statistically different in the two groups of patients. Although it might be argued that these delays in diagnosis did not impact on long term survival, we did find a significant delay to the initiation of treatment. This may have several implications: firstly the assessment of patients for surgery would have been delayed during which time staging migration might have occurred. We did find that there was a significant difference in the percentage of patients undergoing surgery between those patients who had a missed abnormality on chest x ray and those who did not, however the numbers were small. Secondly this delay may have resulted in unnecessary prolongation of symptoms before palliative treatment was offered. Thirdly experience suggests that a perceived diagnostic delay is distressing for the patient and family. In some instances this may prompt consideration of litigation—indeed in the United States the second most common reason for litigation against radiologists is failure to diagnose lung cancer on a chest radiograph.⁹

Although no similar study has been performed in the UK to date, results from Europe suggest a similar error rate.¹⁰ Other studies have reported even higher rates of missed diagnosis but these were heterogeneous populations which included screening studies or patients known to have a malignancy elsewhere.^{11–13} We believe our patients were representative of the general population of lung cancer cases seen in our hospital, although the initial 100 patients only represent about one third of the lung cancer cases seen that year. The identification of cases from pathology records indicates either that a diagnostic biopsy or a resection specimen was available and we studied only local patients (to ensure we "captured" all recent radiographs) thereby excluding those referred from outside the district specifically for surgical treatment. In our study the most common reason for an error to occur was failure to recognise an abnormality on the x ray. It is widely recognised that there are areas on the chest x ray where lesions can easily be missed: behind the clavicle, heart and diaphragm, at the hilum and pleural lesions "en face". The majority of the unrecognised abnormalities in our study were at the hilar region, where distinction from a prominent pulmonary artery is often difficult. In a previous lung cancer screening study 65% of lung cancers in the hilar region were not recognised.¹⁰ Of the missed peripheral opacities in our study the majority (80%) were in the upper lobes, in line with other studies.^{14–16}

Some of the errors, such as a failure to act on a correct report issued by a radiologist (5%) or failing to follow up suspected lesions (11%), may have been avoided if an investigative protocol was in place. Local arrangements will vary but possible solutions could include automatic referral to a chest clinic or a recommendation in the report to do so. The error of failing to recognise an abnormality can never be totally prevented, but access to old films and relevant clinical information may alert the radiologist. It has also been shown elsewhere that optimising reporting conditions and double reporting (two radiologists reporting the same x ray) reduces observer error.¹¹ The exclusion of 22 patients in this study, due to failure to retrieve previous films, highlights the practical difficulties of ensuring old films are available for comparison when chest x rays are reported. Not surprisingly small

Summary and learning points

- Missed diagnosis of lung cancer on a chest x ray is common and leads to a delay in assessment and initiation of treatment.
- The common sites for abnormalities to be missed are at the hilar regions, or where other structures may overlie the lesion (for example, clavicle, heart, ribs).
- Heightened awareness of the problems of diagnosing lung cancer is important for all doctors working in primary and secondary care.
- Efficient and rapid investigative pathways should be available for all patients with chest x ray abnormalities suspicious of lung cancer.

opacities are more likely to be overlooked,¹⁰ and it is recognised that lesions of less than 1 cm can rarely be detected on plain chest radiography. Low dose computed tomography is more sensitive^{17–19} and may well become the investigation of choice at least in high risk patients with new respiratory symptoms.

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