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ORIGINAL ARTICLE

Resource savings in the single reading of plain radiographs by oncologist only in cancer patient follow-up: A randomized study

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Abstract
The aim of this study was to estimate the need for a radiologist's clinical report in the interpretation of plain radiographs in cancer patient follow-up. Consecutive new cancer patients receiving primary treatment were randomized between two arms with different diagnostic modes: a double-reading arm (an oncologist and then a radiologist independently interpreted plain radiographs) and a single-reading arm (radiographs interpreted by an oncologist only; if necessary a radiologist's clinical report was obtained on separate request). Altogether 869 eligible patients participated. No differences were found in the total number of plain radiographs between the two arms. The number of radiologists was 20 and there were 28 oncologists. A separate clinical report was requested from a radiologist in 44% of all plain radiographs in the single-reading arm. This saving of radiologists' work (56%) took place without detriment, as the indicators of earliness of diagnosis were the same in both arms. The role of the radiologist should be more in consultation than in routine interpretation during follow-up.

Introduction

Radiological examinations (plain radiography and special examinations) form part of the overall follow-up after primary treatment. The most common practice worldwide is the interpretation by radiologist and discussing the radiological examination with the oncologist in a daily session. In many Finnish hospitals the radiologist and oncologist each view plain radiographs separately, the oncologist later receiving the radiologist's clinical report.

The significance of the interpreter of plain radiography has not hitherto attracted scientific interest; the purpose of our study was to evaluate whether the interpretation of an oncologist alone was sufficient (single reading) compared with the separate viewing of radiologist and oncologist supplemented with a clinical report by the radiologist (double reading). Here we report the need for a supplementary clinical report by a radiologist in the interpretation by single reading of plain radiographs in cancer patient follow-up. We also estimate the effect of experience, trainee vs. specialist, on this need for double reading in the single-reading setup.

In a previous paper we showed that single reading resulted in no delay in diagnosis of recurrence and, hence double eading had no survival benefit [1].

Material and methods

All consecutive cancer patients at the Department of Oncology in Tampere University Hospital during the period 1 November 1991 to 31 May 1995 were included in the trial. All had microscopically confirmed new cancer. The participants were randomized subsequent to primary treatment. Patients with testicular cancer were excluded, as well as those whose follow-up was arranged by other centres. Eligible patients were randomly allocated to one of two arms: a double-reading arm with a radiologist and an oncologist independently interpreting the plain radiographs, and a single-reading arm with an oncologist interpreting routinely and a radiologist only upon specific request by the oncologist. The total number of randomized patients was 1115. The basis for randomization was the date of birth recorded in the patient's personal identity number.

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Patients born on odd-numbered days of the month were allocated to the double-reading arm and those born on even-numbered days of the month to the single-reading arm.

Radiological follow-up comprised plain radiography of lungs and skeleton and special examinations in conjunction with specifically scheduled or spontaneous outpatient visits. Clinical follow-up with special examination was decided by the oncologist regardless of the research arm. The patients participated in the study after randomization until the end of follow-up, i.e. either death, moving outside the hospital area, transfer to another hospital for follow-up, or until 31 Decembr 1997. The findings were analysed by the randomized arms. Differences in the distributions of background variables were tested by the χ^2 test. The level for statistical significance was $p < 0.05$.

In the entire period of follow-up there were 28 oncologists receiving patients in the outpatient clinic. These included 11 specialists and 17 doctors in training. Follow-up visits made to doctors in training amounted to 39.4% of the total visits in the double-reading arm and 37.8% in the single-reading arm (Figure 1). The total number of radiologists interpreting plain radiographs during the entire period of the study was 20, the figure comprising 7 specialists and 13 doctors in training.

In both arms the radiographs were first sent to the oncological clinic for viewing by the oncologist. In principle, the procedure and time used by the oncologist was identical in both arms. The actual time used by the oncologist for viewing the radiographs was not evaluated, as the oncologist interpreted them during the patient's visit with routinely pre-fixed times.

After the patient's visit to the oncologist the radiographs were sent to the radiological department, where all radiographs in the double-reading arm were interpreted, as well as those of the single-reading arm for which a clinical report was specifically requested. The reason for request in the single-reading arm was not available to the radiologist. The time that a radiologist used per clinical report was estimated by measuring the time used by two radiologists and two doctors in training. The measured total time included hanging of the films on the viewing board, evaluation of the films, dictation, and removal of the films, and was measured for 20 patients' radiographs per doctor. The time ranged from 2 minutes to 20 minutes, with an average of 10 minutes.

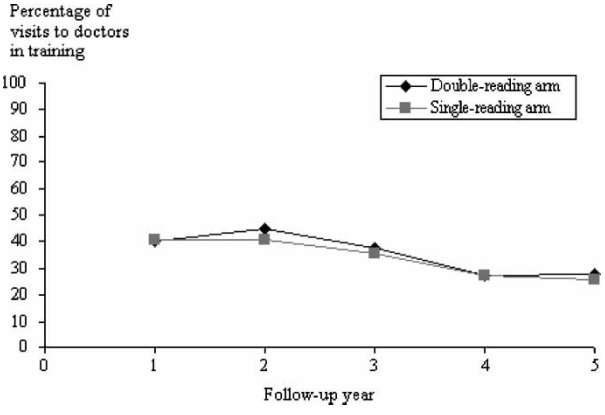

Figure 1. Proportion (%) of visits to doctors in training among all visits to doctors by year of follow-up and research arm.

Altogether 1 115 patients were randomized and the final study included 869 patients. In total 246 patients were excluded from the study due to the following errors in randomization: Patients were either randomized before the end of primary treatment or after the first follow-up visit; in total 122 (66/56). There were 82 (43/39) patients transferring to follow-up after residual treatment. They were not originally part of the study and were excluded. There were 15 (9/6) patients without microscopic confirmation of cancer, and they were not included in the study. There were 14 (6/8) patients erroneously randomized, while transferring to follow-up elsewhere. Two patients in the double-reading arm died before the first follow-up visit. Ten clinical reports by radiologists on plain radiographs were issued erroneously without request and these patients were removed from the data. One patient with cancer of the testes was randomized into the double-reading arm, and by reason of his cancer he was not part of the reasearch. Altogether, of those patients removed for reasons of randomization errors, 132 should have been included in the research, 66 in each arm.

Of the 869 patients included, 452 (52.0%) were randomly allocated to the double-reading arm and 417 (48.0%) to single reading. The difference was not statistically significant after allowing for the larger number of odd-numbered days in a year. There were 93 (54/39) patients whose cancer was present during the whole period of the study. There were 657 (75.6%) women and 212 men (24.4%) in the whole cohort (Table I). No statistically significant difference was noted between the arms in the proportions of women and men ($p = 0.29$). Breast cancer was the most common cancer (59.4%), both in the material as a whole and in the respective research arms (Table II). This also explains the larger proportion of women in the data. The average age of the patients was 58.7 years (range 21–94), in the double-reading arm 59.0 and in the single-reading arm 58.3 years.

The cancer diagnosis had been confirmed histologically in almost all cases (96.7%). The number of local tumors (the cancer had not disseminated or

Table I. Patient characteristics.

Characteristic	Double reading arm		Single reading arm	
	n	%	n	%
Sex				
Male	117	25.9	95	22.8
Female	335	74.1	322	77.2
Age				
−54	167	37.0	160	38.4
55–64	114	25.2	105	25.2
65–74	104	23.0	119	28.5
75–	67	14.8	33	7.9
All patients	452	100.0	417	100.0

this had not been suspected) was greater in the single-reading (247; 66.2%) than in the double-reading arm (237; 59.1%) ($p = 0.04$) (see Table II). Patients with lymphoma had mainly (70.5%) stage I–II tumors in each arm.

The total number of radiological examinations in the whole study was 6 636 during the five follow-up years. Indications for follow-up examinations were: routine after a predetermined period 65.7%, negative effects of treatment 1.5%, suspected recurrence 8.7%, uncertain findings 7.5%, other cancer related 2.9%, and other non-cancer related 13.7%. The number of plain radiographs for the single-reading arm patients was 2 144, which was 65.1% of all examinations and in the double-reading arm 2 207 (66.0%) with no statistically significant difference between the arms ($p = 0.20$). Chest radiography was the most common approach in plain radiography in both arms (86.0% and 84.3%), with no statistically significant difference between the arms ($p = 0.14$). For each arm more chest radiographs were taken in the first year of follow-up than in any subsequent year (Table III).

Separate consent was not requested from the patient, as the radiographs were in both arms interpreted by the oncologist, and it was possible to request a radiologist's report in all cases. In general, informed consent is not required in modifications of clinical practice. The design was approved by the Ethical Committee of Tampere University Hospital.

Results

There were altogether 1 927 plain radiographs in the single-reading arm, for which 856 (44.4%) the oncologist also requested viewing by the radiologist. In the first year clinical reports were requested in 40.6% of cases and in the following years the need for clinical reports increased (Table IV). The ratio of requests by oncologist for clinical reports to the total number of oncologist visits for the entire duration of follow-up was 0.17 (360/2128); the corresponding figure for doctors in -training was 0.23 (301/1297) i.e. 35% more. The difference was statistically significant ($p < 0.001$), and increased throughout the first four years (Figure 2).

An oncologist separately requested a radiologist's report on 39.2% of all chest radiographs (Table V).

Table II. Disease characteristics.

Characteristic	Double-reading arm		Single-reading arm	
	n	%	n	%
Confirmation				
Histologically	436	96.5	404	96.9
Cytologically	16	3.5	13	3.1
Stage of disease				
Local	237	59.1	247	66.2
Non-local	164	40.9	126	33.8
Primary site				
Breast	267	59.1	249	59.7
Lung	59	13.1	47	11.3
Lymphoma	51	11.3	44	10.6
Skin	43	9.5	45	10.8
Thyroid	16	3.5	16	3.8
Other	16	3.5	16	3.8
Treatment				
Surgery	105	23.2	116	27.9
Surgery and radiotherapy	122	27.0	121	29.0
Surgery, radio- and/or medical treatment	159	35.2	123	29.5
Radiotherapy and/or medical treatment	60	13.3	56	13.4
No treatment	6	1.3	1	0.2
All patients	452	100.0	417	100.0

Table III. Radiological examinations by research arm.

	Double-reading arm	Single-reading arm
Radiological examinations in total	3344	3292
Plain radiographs	2207	2144
Chest radiographs	1897	1808
Skeletal radiographs	310	336
Special examinations	1137	1148

The requests were more frequent for skeletal radiographs, and the proportion of these varied from 61% to 90% depending on site.

The savings thus involved in terms of radiologists' work in the single-reading arm were 1 071 (55.6% of all) radiographs. The savings varied from 10% (spine radiograph) to 60% (chest radiograph) depending on the type of plain radiograph (see Table V). At 10 min per patient, this comprised 180 h of radiologist work.

Discussion

The number of cancer patients under follow-up is increasing, mainly due to the ageing of the population, the improved results of cancer treatment, and the improved prognosis for cancer owing to early diagnosis. A future challenge in healthcare will be not only the growing number of cancer cases but also the larger number of those in follow-up. It is thus important to estimate how the healthcare system will continue to cope with the treatment of cancer and follow-up while maintaining at least the level of performance achieved so far. The degree to which the goals of follow-up are achieved depends largely on disease and patient. There are ample findings in the literature according to which the significance of routine plain radiography during follow-up must be questioned [2–12]; many, however, are based on selected series. There is an abundance of studies, mostly retrospective, on the follow-up of breast cancer and its significance for the detection of recurrence and survival after recurrence [12–21].

Table IV. Number of plain radiographs (n) on which a radiologist's clinical report was requested separately and their percentage (%) proportion of patients in single-reading arm.

	Single-reading arm		
Year of follow-up	n	%	Total
1	297	40.6	731
2	234	48.4	483
3	167	42.5	393
4	107	47.6	225
5	51	53.7	95
Total	856	44.4	1927

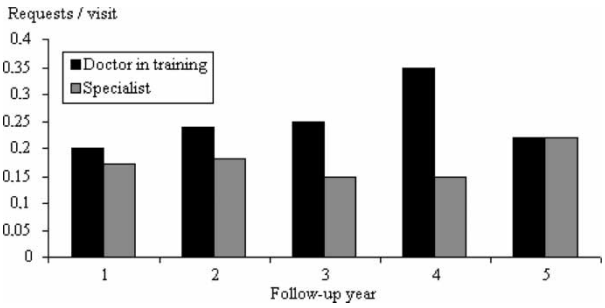

Figure 2. Number of requests for clinical reports by doctors in training and by specialists per visit by year of follow-up among patients in the single-reading arm.

The radiological follow-up of cancer patients forms part of the overall follow-up after primary treatment, its first objective being to detect recurrence of cancer as early as possible. Despite the development of new radiological methods, plain radiography continues to be primary in examining the lungs and skeleton. Most earlier studies have been non-randomized and retrospective. There are only two prospective randomized studies on the efficacy of plain radiography in the follow-up of breast cancer patients [7,11]. The present research setting with randomization maximized the comparability of double and single reading. In normal clinical practice the contribution of the radiologist is determined among other things by the type of hospital and thus by the domicile of the patient, the anatomical location of the cancer, its malignity and degree of dissemination, and the age and state of health of the patient. Such factors are also prognostic for the disease, which may reflect selection and selectivity in addition to the radiologist's influence in non-experimental research. To the best of our knowledge the need for a clinical report by a radiologist in the interpretation of plain radiographs has not previously been studied in an experimental setting.

Table V. Number (n) of single-reading arm patients' chest and skeletal radiographs on which the oncologist separately requested a radiologist's clinical report and their percentage distribution (%) of all chest and skeletal radiographs.

	Single-reading arm		
Radiograph	n	%	Total
Chest	661	39.2	1686
Spine	72	89.9	81
Upper limb	31	77.5	40
Pelvis	18	81.8	22
Lower limb	27	61.4	44
Ribs	33	89.2	37
Other	14	82.4	17

The common practice in follow-up of cancer patients is the interpretation by radiologist and viewing of the radiological examination by the oncologist, commonly conducted by the radiologist in a daily session. Owing to limited human resources the practice is sometimes changed to routine interpretation of all radiographs by the radiologist with the availability of the statement subsequently for the oncologist, who reads all the films. In the practice of Tampere University Hospital only the most problematic cases were brought to the common session.

The actual co-work of oncologist and radiologist has changed during recent years, e.g. because of rapid changes in imaging technology. Our study still has practical relevance in the planning of follow-up of cancer patients. There remain many areas with use of plain films in cancer follow-up. Our results also give indirect support to move the follow-up from central hospital level to health centres, especially in the low population density areas, such as the northernmost parts of the Nordic countries. Our study also has more general relevance, to demonstrate how to evaluate the organization of services through a properly designed, randomized clinical trial.

The precondition for resource savings is no loss in quality of the service, which we measured by earliness of diagnosis of recurrence and survival. As the request for review by radiologist is related to probability of recurrence and survival, only a randomized design gives unbiased results. In this present study approximately the same number of radiological examinations were undertaken in each of the randomized arms, which is further evidence of the success of the randomization and the comparability of the patients in both arms. Separately requested clinical reports by a radiologist accounted for less than one half of all plain radiographs in the single-reading arm. The amount of these requests, 44.4%, is relatively high for routine radiographs, but it proves that the oncologists need and also request assistance just for added security. In a previous paper [1] we showed that the earliness of diagnosis of recurrence and survival were the same in both arms. In the present paper we estimated the change in clinical practice and found that in 55.6% of the viewings the oncologist did not need the interpretation of a radiologist. No success in changing practice would imply this figure to be 0%. However, the savings (55.6%) in radiologists' work may be counterbalanced by an increase in oncologists' reading time as more time might have been assumed for the rest (44.4%) of the patients. In the present design this was unlikely, as each visit was assigned a fixed time.

We conclude, on the basis of the considerable savings without notable detriment, that the contribution of the radiologist could be focused on interpretation of radiological examinations and consultation rather than on plain radiographs during follow-up. This would save resources of about one week per radiologist and year, and optimize the use of radiologists' work. The capacity of radiologists released from routine dictation could be harnessed by increasing the meetings between radiologists and oncologists at which problem situations arising could be tackled and at which doctors with less experience would have an opportunity to learn.The trial was supported by the Medical Research Fund of Tampere University Hospital, University of Tampere and the Pirkanmaa Cancer Society.

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