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Time management in radiation oncology: development and evaluation of a modular system based on the example of rectal cancer treatment

The DEGRO-QUIRO trial

About half of all cancer patients receive radiation therapy in the course of tumor treatment [2, 4, 5]. Radiotherapy (RT) or chemoradiotherapy (CRT) and surgical resection are important elements of multimodality treatment for patients with locally advanced rectal cancer [8]. In addition to the necessary technical equipment, well-trained technicians, medical physicists, and radiation oncology nurses are essential for successful radiotherapy [6, 8].

However, there is almost no evidence-based data available on the time required by the various professional groups involved in radiation oncology to deliver care to the patients before, during, and after radiation oncology treatment, including treatment planning (initial examination, informed consent process, aftercare and chemotherapy, or other medication treatments) and follow-up procedures. In 2006, the German Society of Radiation Oncology (DEGRO), therefore, commissioned a panel of experts from four hospitals in Germany (Rostock, Bamberg, Offenbach, and Düsseldorf) to develop in collaboration with the company Prime Networks AG a modular system that makes it possible to quantify the times required by the various professional groups involved in the radiation oncology process. Earlier analyses [12] dealt primarily with the revenue situation in Germany in the 1990s, but these data have limited applicability today. The calculations by Lievens et al. [7] are based on existing staff and existing equipment and calculate the costs of radiation oncology treatment of cancer in different organ systems.

The goal of the present study was, therefore, to develop individual modules, measure the corresponding time requirements, analyze the collected data, and to describe the implications. This investigation was the basis for further evaluation of other, especially individual modules for organ tumor and radio-oncological treatments (head and neck tumor, breast cancer, prostate cancer, interstitially radiotherapy, chemotherapy, and hyperthermia); some of the data have been published [3] or planned to be published (Blank et al.).

Material and methods

Measurement principles

A preliminary panel (HS, RF, and WP) divided the work associated with providing radiation oncology treatment into modules based on the example of rectal treatment. After review by an independent expert panel (HJT and WB), the proposed modular system was used by independent observers to measure the time required to complete the specified steps based on the example of rectal cancer treatment. The transferability of the model to other types of cancer was assessed by the expert panel.

The work associated with providing radiation oncology treatment was divided into the following modules (**Fig. 1a, b, c, d, e**): preparatory steps (**Fig. 1b**), treatment planning (**Fig. 1c**), administration of radiation therapy (**Fig. 1d**), final consultations and follow-up appointments (**Fig. 1e**).

The investigators described which activities had to be performed, which professional groups were involved, and how much time was required for each of these modules. Every module does not necessarily apply in every case for various reasons. For example, conventional irradiation planning was performed in some cases, while virtual irradiation planning was performed in others. The appropriate modules were completed accordingly. By using the modular system, the individual steps of treatment can be individually adapted for all of the participating hospitals.

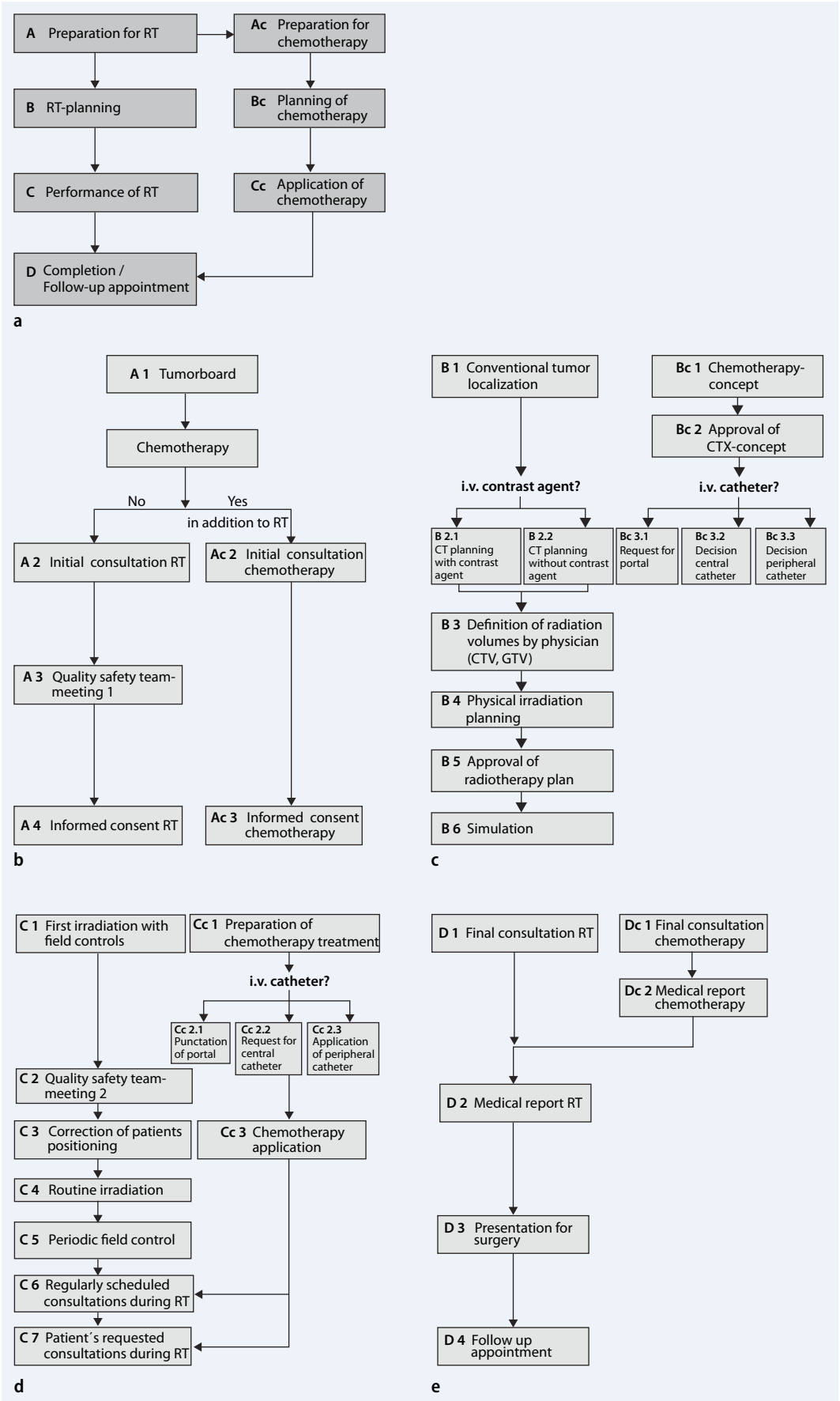

Fig. 1 ◀ Overview: module system (**a**). Allocation steps: preparation of radiotherapy/chemotherapy (**b**), RT planning/chemotherapy planning (**c**), radiotherapy and chemotherapy delivery (**d**), completion/follow-up appointment (**e**)

To provide an example of the contents, selected modules are described in detail below.

Initial consultation for radiotherapy

The steps in this module consist of entering referral data regarding the tumor stage, general medical history, and physical examination in the patient's record, obtaining missing data (e.g., by ordering tests or a copy of test results), and scheduling appointments for further steps of treatment.

Routine irradiation

This module defines which professional groups are involved (physician, technicians, and/or physicist) and the time it takes to load the irradiation data and transfer the files to the treatment unit, as measured from the time of calling out the patient's name and escorting the patient from the waiting area to the dressing room, positioning and adjusting the patient on the accelerator, delivering the irradiation, escorting the patient out of the treatment room, scheduling the next radiation appointment, and recording the data. Multiple measurements were taken at the participating hospitals in order to detect the effects of equipment failure and data transmission problems as well as effects in elderly and frail patients.

Measurement procedure

An independent measurement system was used, i.e., the measurements were conducted independent of the persons providing care. This was accomplished by independent observers (students and documentalists), who were present in the departments and measured the precise times required for the individual examinations, tasks, etc. using a stopwatch. The data collected by these individuals was sent for central data entry and analysis.

Results

A total of 1,769 data sets collected from 63 rectal cancer patients (18 from Bamberg, 14 from Düsseldorf, 15 from Offenbach, and 16 from Rostock) who received radiation oncology treatment at the participating hospitals were included in the analysis.

Abstract · Zusammenfassung

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Time management in radiation oncology: development and evaluation of a modular system based on the example of rectal cancer treatment. The DEGRO-QUIRO trial

Abstract

Purpose. The goal was to develop and evaluate a modular system for measurement of the work times required by the various professional groups involved in radiation oncology before, during, and after serial radiation treatment (long-term irradiation with 25–28 fractions of 1.8 Gy) based on the example of rectal cancer treatment.

Materials and methods. A panel of experts divided the work associated with providing radiation oncology treatment into modules (from the preparation of radiotherapy, RT planning and administration to the final examination and follow-up). The time required for completion of each module was measured by independent observers at four centers (Rostock, Bamberg, Düsseldorf, and Offenbach, Germany).

Results. A total of 1,769 data sets were collected from 63 patients with 10–489 data sets per module. Some modules (informed consent procedure, routine treatments, CT planning) exhibited little deviation between centers, whereas others (especially medical and physical irradiation planning) exhibited a wide range of variation (e.g., 1 h 49 min to 6 h 56 min for physical irradiation planning). The mean work time per patient was 12 h 11 min for technicians, 2 h 59 min for physicists, and 7 h 6 min for physicians.

Conclusion. The modular system of time measurement proved to be reliable and produced comparable data at the different centers. Therefore, the German Society of Radiation Oncology (DEGRO) decided that it can be extended to other types of cancer (head and neck, prostate, and breast cancer) with appropriate modifications.

Keywords

Radiotherapy · Rectal cancer · Medical staff · Time requirement

Zeitmanagement in der Radioonkologie: Entwicklung und Evaluation eines Modulsystems am Beispiel der Behandlung des Rektumkarzinoms. Die DEGRO-QUIRO-Studie

Zusammenfassung

Ziel. Entwicklung und Evaluation eines Modulsystems zur Zeiterfassung vor, während und nach einer Bestrahlungsserie bei den beteiligten Berufsgruppen in der Radioonkologie am Beispiel des Rektumkarzinoms (Langzeitbestrahlung mit 25- bis 28-mal 1,8 Gy).

Material und Methoden. Von einer Expertengruppe wurden die Arbeitsschritte in der Radioonkologie in einzelne Module gegliedert (Aufklärung und Voruntersuchungen, Bestrahlungsplanung, Durchführung der Bestrahlung, Abschlussuntersuchungen und Nachsorge). An 4 Zentren (Rostock, Bamberg, Düsseldorf, Offenbach) wurden von unabhängigen Personen die Messungen des Zeitaufwandes durchgeführt.

Ergebnisse. 1.769 Datensätze von 63 Patienten wurden erfasst. Pro Modul konnten zwischen 10 bis maximal 489 Datensätze erfasst werden. Einzelne Module (Aufklärung, Routinebestrahlung, Planungs-CT) zeigten kaum Abweichungen zwischen den Zentren, andere Module, insbesondere die medizinische und physikalische Bestrahlungsplanung wiesen deutliche Unterschiede auf (z. B. physikalische Bestrahlungsplanung: 1 h 49 min bis 6 h 56 min). Pro Patient ergibt sich in Summe folgender Zeitaufwand: MTRA 12 h 11 min, Physiker 2 h 59 min, ärztliches Personal 7 h 6 min.

Schlussfolgerungen. Das Modulsystem und die Durchführung der Messungen erwiesen sich als zuverlässig und die Daten zwischen den einzelnen Institutionen als vergleichbar. Es wurde daher von der DEGRO beschlossen, dass die erarbeiteten Module mit entsprechenden Modifikationen für weitere Tumoren (Kopf-Hals-Tumoren, Prostatakarzinom, Mammakarzinom) angewendet werden können.

Schlüsselwörter

Radiotherapie · Rektumkarzinom · Medizinisches Personal · Zeitbedarf

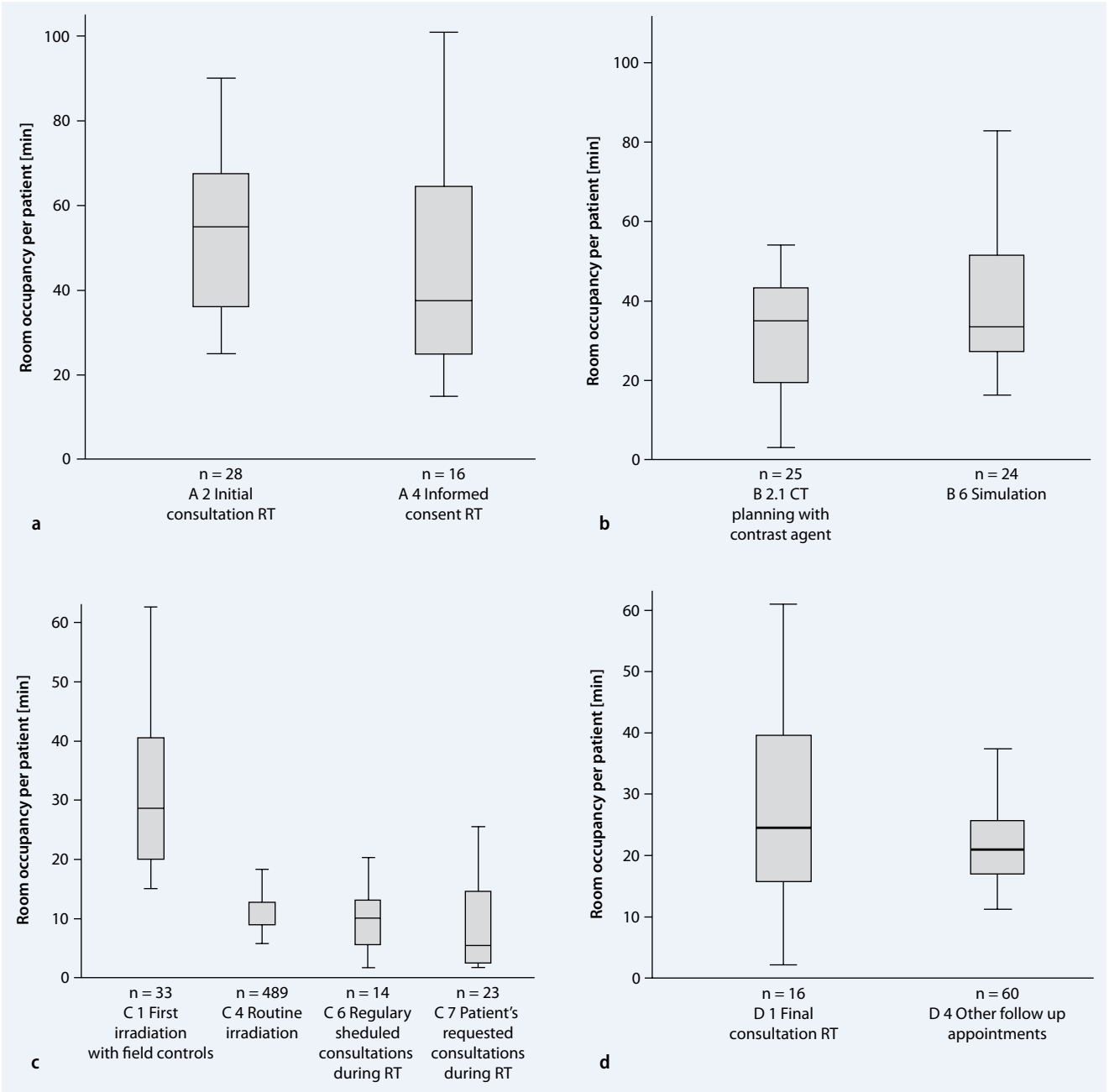
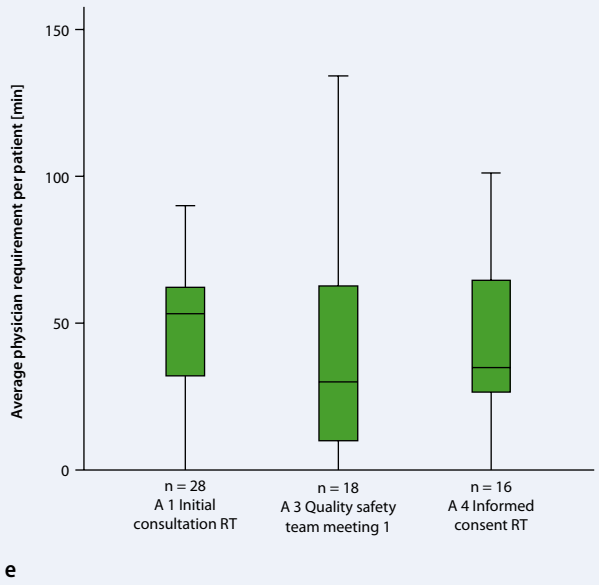
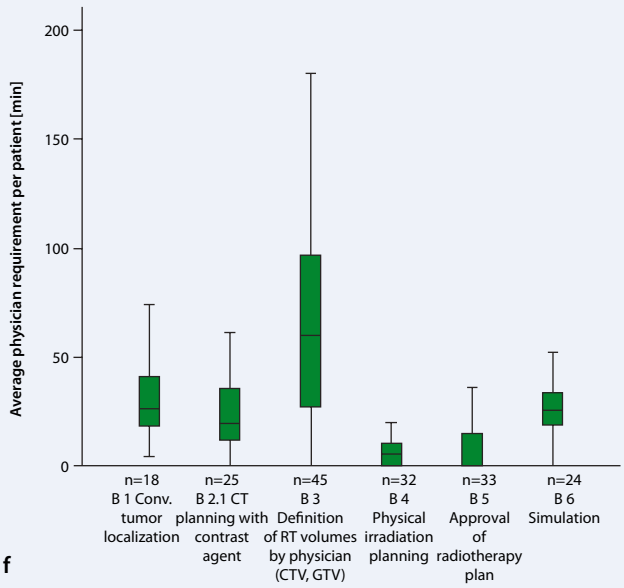


Fig. 2 ▲ Room occupancy for preparation of radiotherapy (**a**), RT planning (**b**), radiotherapy delivery (**c**), and completion/follow-up appointment (**d**) for all involved professional groups. Median values with 25% and 75% percentile are shown. Staff requirement for RT planning for preparation of radiotherapy (**e**), RT planning (**f**, **g**), radiotherapy delivery (**h**, **i**) and completion/follow-up appointment (**j**). Median values with 25% and 75% percentile are shown

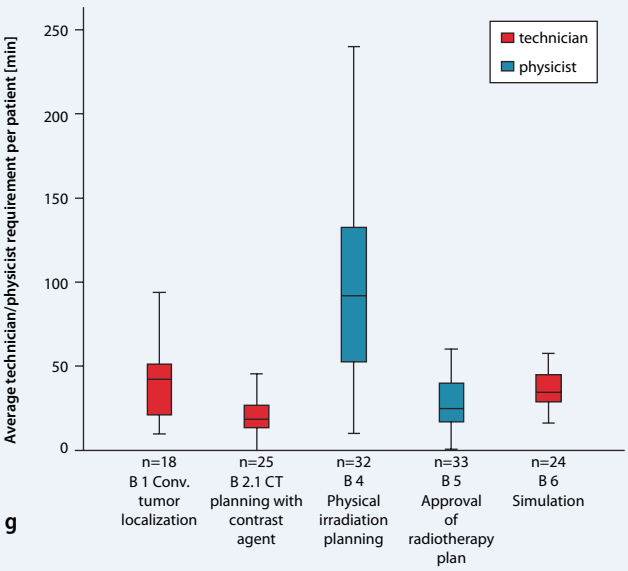
Fig. 2 ► continued


Average physician requirement per patient [min]
150
100
50
0
n = 28
A 1 Initial
consultation RT
n = 18
A 3 Quality safety
team meeting 1
n = 16
A 4 Informed
consent RT

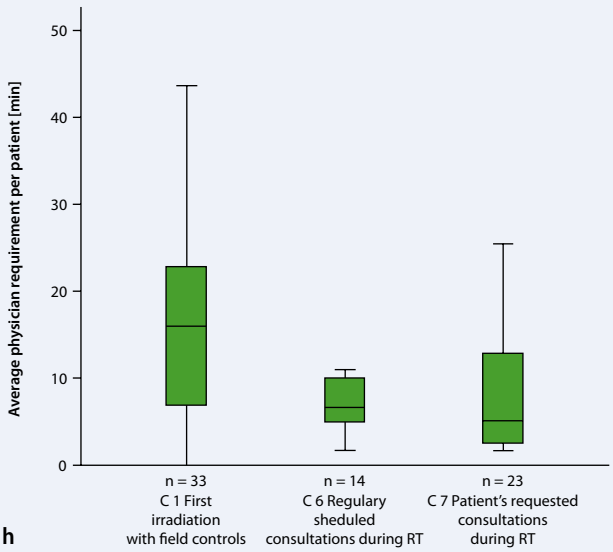
e


Average physician requirement per patient [min]
200
150
100
50
0
n=18
B 1 Conv.
tumor
localization
n=25
B 2.1 CT
planning with
contrast
agent
n=45
B 3
Definition
of RT volumes
by physician
(CTV, GTV)
n=32
B 4
Physical
irradiation
planning
n=33
B 5
Approval
of
radiotherapy
plan
n=24
B 6
Simulation

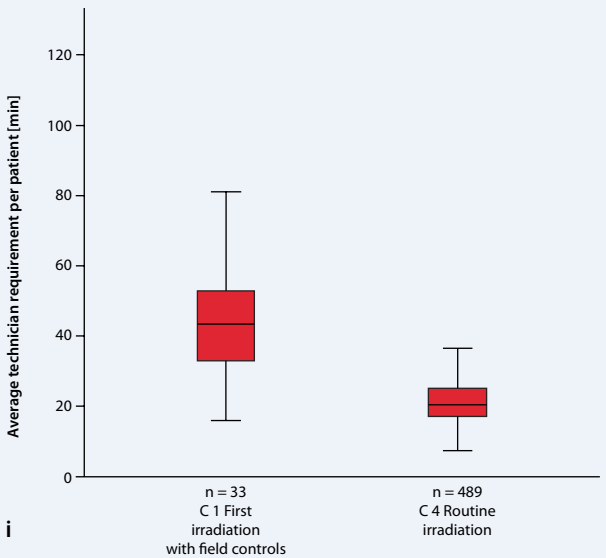
f


Average technician/physicist requirement per patient [min]
250
200
150
100
50
0
technician
physicist
n=18
B 1 Conv.
tumor
localization
n=25
B 2.1 CT
planning with
contrast
agent
n=32
B 4
Physical
irradiation
planning
n=33
B 5
Approval
of
radiotherapy
plan
n=24
B 6
Simulation

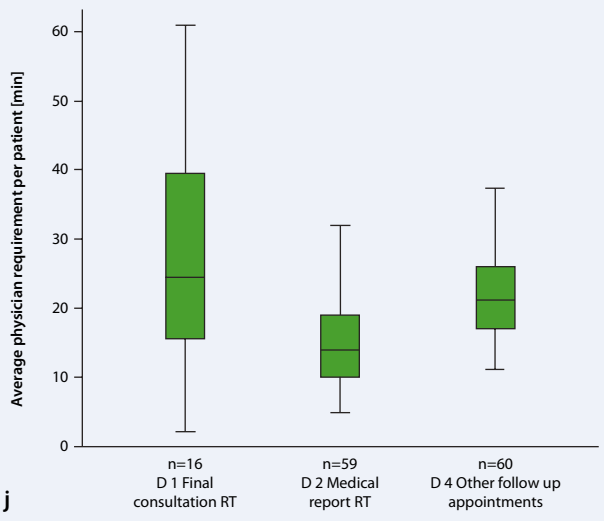
g


Average physician requirement per patient [min]
50
40
30
20
10
0
n = 33
C 1 First
irradiation
with field controls
n = 14
C 6 Regulary
sheduled
consultations during RT
n = 23
C 7 Patient's requested
consultations
during RT

h


Average technician requirement per patient [min]
120
100
80
60
40
20
0
n = 33
C 1 First
irradiation
with field controls
n = 489
C 4 Routine
irradiation

i


Average physician requirement per patient [min]
60
50
40
30
20
10
0
n=16
D 1 Final
consultation RT
n=59
D 2 Medical
report RT
n=60
D 4 Other follow up
appointments

j

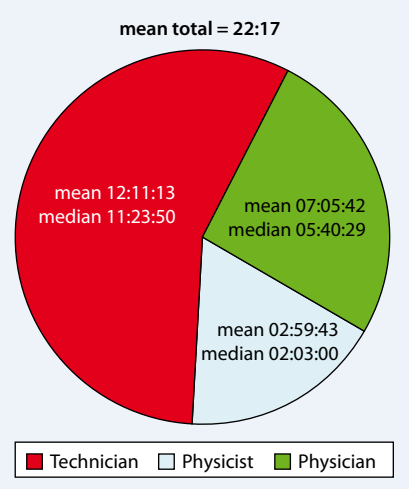


Fig. 3 ▲ The overall workload time (mean and median values) of all involved professional groups for treating a rectal cancer patient with radiotherapy (chemotherapy excluded) is about 22 hours and 17 min (mean value)

The modules containing the largest number of data sets were "routine irradiation" ($n = 489$) and "periodic field control" ($n = 192$). In general, the number of data sets per module ranged from 10–60.

Time per module as a function of room occupancy time and personnel presence

The room occupancy times and duration of presence of the radiation oncology specialist, radiation oncology resident, medical physicist, and technician varied greatly from one module to another. Room occupancy and personnel presence (physician, technician, and physicist) per patient are shown in **Fig. 2a, b, c, d, e, f, g, h, i, j**.

The main modules showed remarkable consistency between the individual departments. For example, the mean time for an initial consultation was approximately 53 min (**Fig. 1a**), ranging from 25 min (minimum) to 1 h 30 min (maximum).

For CT planning with contrast, the room occupancy time was a mean 35 min (range 12–54 min, **Fig. 2b**). In this case, a physician (**Fig. 2f**) and a technician (**Fig. 2g**), who were present for 20 min and 26 min, respectively, were involved in the delivery of treatment.

Distinct differences were observed in irradiation planning. Medical irradiation planning took a mean 1 h 15 min, with extremes ranging from 11 min to 4 h 4 min. The same applies to physical irradiation planning, which required a mean 1 h 49 min, ranging from 14 min to 6 h 56 min (**Fig. 2b**).

In contrast, the times for radiation and the duration of irradiation on the accelerators were very constant. The first irradiation with field controls still exhibited deviation, with times ranging from 15 min to 1 h 22 min, but routine irradiations were performed with an average room occupancy time of 11 min. The shortest routine irradiation took 5 min, whereas the longest took 1 h 12 min (**Fig. 2c**).

The times for consultations during radiation therapy (**Fig. 2c**) were also very constant (mean 9 min; range 1.20–20 min). Follow-up appointments (**Fig. 2d**) took a mean 23 min (range 15–40 min). Thus, the mean work time per patient for completion of the radiation treatment series (25–28 fractions of 1.8 Gy) in patients with rectal cancer was 12 h 11 min for technicians, 2 h 59 min for physicists, and 7 h 6 min for physicians (**Fig. 3**).

Extrapolated to a year and assuming that a physician has an additional 1 h/day of administrative work, 2 h/week of continuing education, and 2 h/week of tumor boards and other nonprocedural work in addition to the procedural time spent with the patients, the total work time per physician was estimated to be 1,262 h/year, corresponding to an annual patient load of 177 patients/physician per year.

Accordingly, the annual patient loads for medical physicists and technicians were estimated to be 383 patients/physicist per year and 120 patients/technicians per year.

The modular system of time measurement proved to be reliable and produced comparable data for the different centers. Therefore, the German Society of Radiation Oncology (DEGRO) determined that it can be extended to other types of cancer (head and neck, prostate, and breast cancer) with appropriate modifications.

Discussion

The proposed modular system of time measurement make it possible to obtain a realistic estimate of the times required for the provision of radiation oncology treatment to patients with rectal cancer by the different professional groups involved. The observed patient loads are in line with specifications of other countries.

Slotmann et al. [10] published the following statistics for radiation oncologists in 17 European countries based on the available guidelines: the recommended number of radiation oncologists per machine is one in Austria, and the patient loads for radiation oncologists ranged from 150 patients/year in Montenegro to 400 patients/year in France (non-university centers), with a median of 250 patients/year. The number of medical physicists specified according to guidelines in 18 countries ranges from 300 in Italy to 750 in Belgium, but 0.37–1 physicist per linear accelerator is recommended in certain cases. Figures for technicians were available for 17 countries, but the differences between the different countries were so great that it was not possible to make an estimate. In summary, this report recommends one radiation oncologist per 250 patients/year (200 patients/year in complex cases), one physician per 450–500 patients/year, and two technicians per linear accelerator.

Our calculations of annual patient loads are in the same range as the published data. Nevertheless, the advantage of the present study is that the estimates are calculated based on direct time measurements obtained by independent observers. Other estimates are either based on general models, population estimates, cancer incidence, or similar statistics [1] or on the current conditions in a given country (e.g., in France by Ruggieri-Pignon et al. [9] and in Japan by Teshima et al. [11]).

Obviously, the analytical approach used in this study also has both strengths and weaknesses, which are outlined below.

Limitations of the study

- Because the time required for resident physician and medical physicist

training was not distinguished, it is not possible to determine the extent to which this may have extended the measured work times in the affected modules.

- Although the type of physician involved in the module was specified (chief physician, radiation oncology specialist, or radiation oncology resident), it was not possible to break down the times for the individual subgroups. One can assume that the time required for completion of the affected modules varied according to the level of training and experience of the physician. Therefore, it cannot be excluded that the extremely long times observed in certain modules (e.g., irradiation planning) may have been due to the fact that training was being conducted and/or that trainee errors had to be corrected by a radiation oncology specialist or medical physicist. In other words, the times may have been shorter if only trained specialists had been involved.
- The fact that some new treatment procedures (particularly intensity modulated radiotherapy) were being introduced during the study period may have increased the times required for irradiation planning in some departments.
- Conventional radiation therapy with 3D planning was the standard procedure performed during the study period, and intensity modulated radiotherapy (IMRT) was the exception. The use of new procedures may have resulted in longer planning and treatment times, as was observed previously by Van de Werf et al. [13] in a study on IMRT and image-guided radiotherapy.

Strengths of the study

The times required for the processes involved in radiation oncology treatment were determined by independent observers. Because effects such as equipment failure, difficulties in patient positioning, and problem cases with unclear questions were included, the analysis gives a more realistic picture than those in which only standard cases are included. The method used excluded subjective estimates of how long it took to complete the tasks and the tendency to underestimate delays throughout the day.

Conclusion

The present study meets the goal of developing and evaluating a modular system for measurement of the work times required by the various professional groups involved in the radiation oncology treatment process as specified by the German Society of Radiation Oncology (DEGRO). Although certainly not flawless, the results provide a constructive basis for future negotiations with insurance carriers.

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Conflict of interest. The corresponding author states that there are no conflicts of interest.

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