THE ROLE AND ORGANISATION OF A MODERN RADIOTHERAPEUTIC LINE IN THE MANAGEMENT OF CANCER PATIENTS.

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At present, there exists several methods to improve the results of radiation therapy. The main three techniques are: altered fractionation, use of radiosensitizers and the improvement of radiotherapy quality. To implement the latter method, different procedures are recommended regarding basic beam dosimetry, machines mechanical precision, particular steps in the radiation therapy chain and work organisation. A large number of departments apply some of these techniques to assure high quality of radiotherapy. Unfortunately, the increasing number of procedures usually causes a lot of problems with work organisation and data flow, which could be a potential source of errors and decrease in the radiotherapy quality. This is a reason why the idea of a system assuring precise synchronisation and supervision of radiotherapy procedures has appeared (Aoki et al., 1987; Nagata et al., 1996; Wong and Chua, 1990).

Consecutive step-procedures of radiotherapy have been linked by using a computerised system, co-ordinating daily work at the department (Aoki et al., 1987; Nagata et al., 1996). At present, complete therapeutic lines, including all devices necessary for treatment planning, radiation delivery, quality beam assurance and computerised supervising systems are available on the market.

One of them (Varian) has been installed, commissioned and operated at the Department of Radiotherapy at the Institute of Oncology in Gliwice. We have accumulated almost nine months of experience with this therapeutic line.

Generally, a therapeutic line is divided into two main parts: a computerised supervising system and a several peripheries such as: a treatment planing system, a simulator, CT, treatment devices, quality beam assurance devices, etc. (Fraass et al., 1995).

The therapeutic line installed at our department comprises a simulator (Ximatron), a 3D treatment planning system (CadPlan), two working linear accelerators (Clinacs) – (the third one is installing) and a computerised supervising system (VARIS) with special extension allowing fast images transfer inside the department (VARIS-VISION).

The scheme of this network is shown in Figure 1.

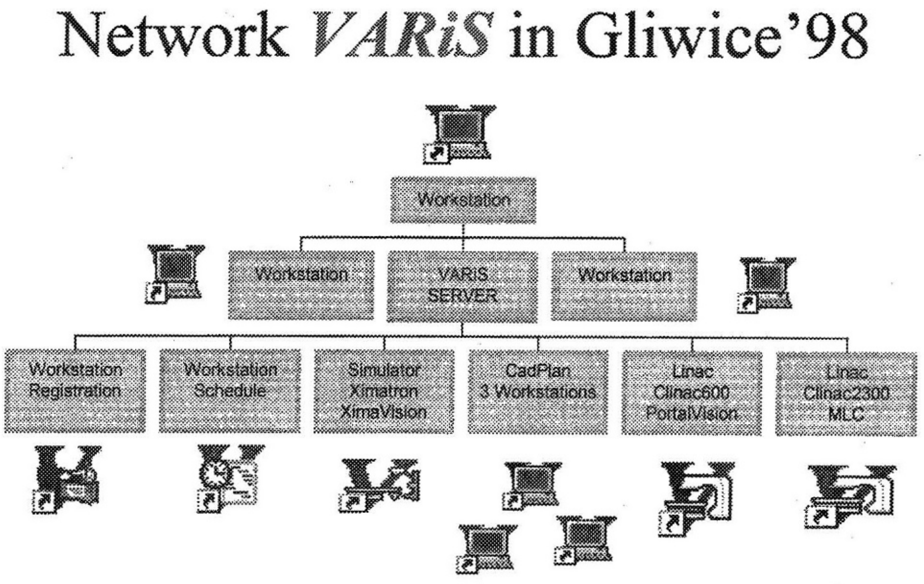

Fig. 1. The Varian network for radiotherapy department.

The CadPlan treatment planning system is based on one server (HP-9000), two work stations (HP-700) and is connected on line to VARIS, CT (Siemens-Sommatom 4+) and to a compensators cutter (Par Scientfic).

Linear accelerators (Clinac 2300 C/D and Clinac 600) are equipped with multileaf collimators, on line verification portal imaging systems and dynamic wedges.

The computerised system used at our department (VARIS) is connected to peripheries, supervises them and is responsible for data flow and storage. The installed hardware of this system is one server (HP) and 5 workstations (HP-Vectra). One workstation is located in the registration room, two stations are installed in accelerator rooms, one station in the treatment planning department and one station in the doctors' room. The VARIS system includes individual Windows compatible applications, used for information management. VARIS is composed of nine main software blocks: registration (initial patient data), treatment chart (treatment course creation), treatment (treatment plan and prescribed doses), simulation (recording of simulation parameters and their transfer to treatment units), reports (reports creation from the VARIS database), charges (financial aspects of radiotherapy), links (standard links to other systems), schedule (patients schedule during treatment planning and delivery) and administration (system configuration in wider users' setting and administrative arrangements).

The graphical scheme of the VARIS application is presented in Figure 2.

VARiS in GLIWICE'98

* REGISTRATION	* TREATMENT
* CHART	* ADMINISTRATION
* REPORTS	* SCHEDULE
* SIMULATION	* LINKS
* CHARGES	

Fig. 2. Varis applications.

The Department of Radiotherapy in our Institute admits outpatients from different hospitals and patients from the other departments of the Institute. For a long time it was not easy to follow daily schedules because the outpatients came for planning and daily treatments very rarely on time. Daily schedules were very often violated and it was very difficult to keep order and programme unchanged. Once therapeutic line was installed the situation has changed almost immediately. It makes us work using with step-by-step procedures (Tab. I) and following daily schedules strictly.

No.	Procedure	Number of step by step activities *	Place and device	Staff	Average time of procedure
1	Clinical evaluation, therapeutic decision and patient schedule planning	10	Examination room Seminar room – VARIS	RO+N RO+S	2 h 35 min.
2	Preliminary simulation – tumour/critical organs volumes, patients contours	18	Simulator room – XIM CT room – CT CadPlan róom - CDP	RO+Techn.+Phys.+ S	4 h 5 min.
3	Treatment planning	19	Treatment Planning Division – CDP, VARIS	RO+Phys.+2 Techn.	8 h 24 min.
4	Individual shielding blocks, immobilisation, MLC, resimulation	13	Mould room, Simulator room, CadPlan room – Par Scient.,CDP, XIM, VARIS	RO+Techn.+Phys.	4 h 50 min.
5	Treatment, dosimetry in vivo, portal imaging, periodic evaluation of tumour/critical organs response	22	Treatment room, Physics department – CL-2300, CL-600, Electr.	RO 2 Techn. Phys. S	22 h 47 min.
6	**Repositioning /changes in treatment parameters (in the case of machine failure – repetition steps 1-5)**	Repetition of steps 1-5			**1 h 54 min.**
7	Therapeutic line maintenance	Not included in the patient's procedure time			
All 5 (6)		82	Radiotherapy Department, Physics Department, Treatment Planning Division	1 RO (0.9) 1 Phys. (0.2) 2 Techn. (1.0) 1 S (0.1) 1 N (0.1)	44 h 35 min.

Table 1. Step-by-step procedures for radical radiotherapy of the head and neck cancer patients using a therapeutic line.

CT – computherized tomography, CDP CadPlan, CL (2300, 600) – linear accelerators, Electr. – electrometer, VARIS – integrating computherized system, XIM – simulator, Par Scient.– block cutter, RO – radiation oncologist, N – nurse, S – secretary, Phys. – physicist, Techn. – technician

* particular activities within one procedure, for example, for procedure no.: patient folder (history of disease) creation, initial patient data input, physical examination, evaluation of additional examinations results, diagnosis verification, etc.

At the beginning, after qualifying the patient for radiation treatment the general strategy of treatment is decided upon weekly departmental meetings. The patient's initial administrative and medical data are input into the system during registration (Fig. 3).

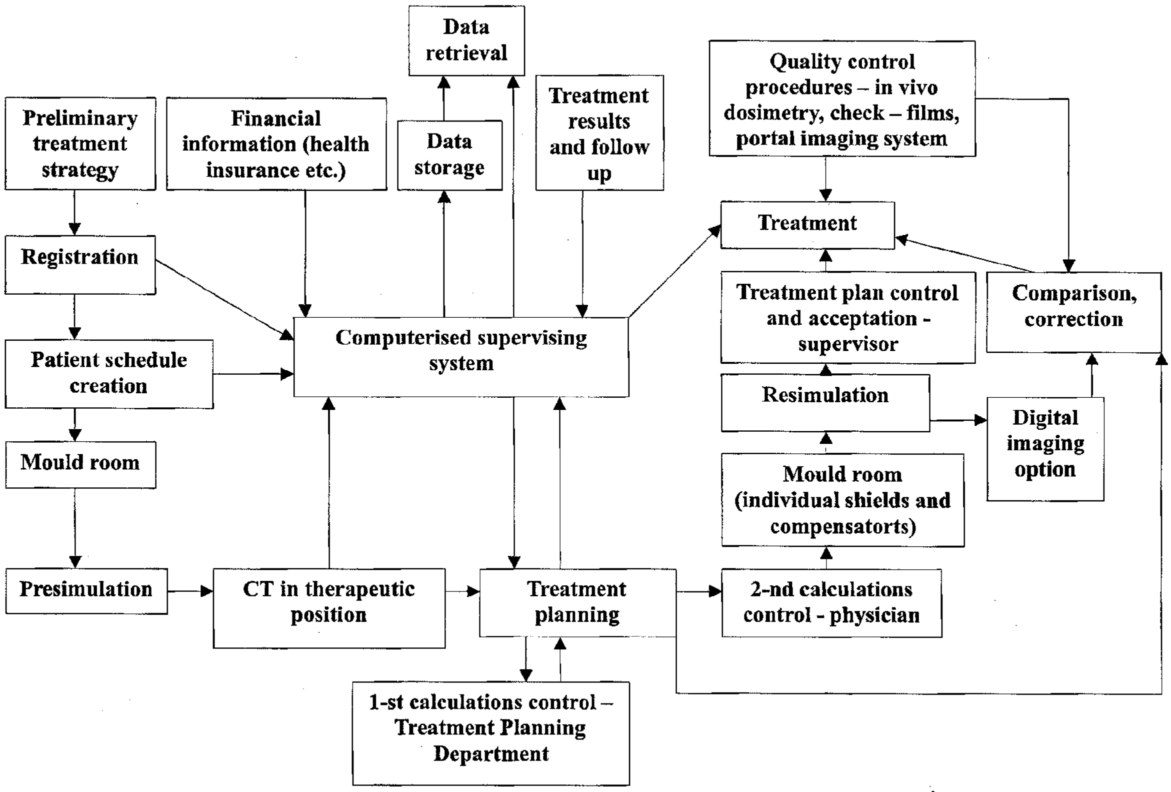

Fig. 3. Consecutive steps of work in the therapeutic line.

The construction of VARIS system constrains proper succession of procedures, complete data input and a very rigid schedule of particular steps in the radiation treatment, so the next step is planning of patient schedule i.e. terms of immobilisation casts making, simulation, CT in the treatment position (contours taking), contouring, treatment planning, individual blocks, tissue compensators, boluses making, resimulation and isodose distribution acceptation. This step is realised using a special module of VARIS which protects from overlapping of the physician, technician and physicist work-time and the procedures times.

After patient immobilisation the first preliminary simulation is carried out. An X-ray simulating image is transformed into a digital image using special software called digital imaging option (DIO), based on its own server (images storage) and connected on line to VARIS. The treatment position of the patient is recorded by a digital camera. This simulation is considered to be definite in cases when the irradiated fields are determined on the skin by a region of lymphatic drainage (for example, postoperative head and neck cancer patients irradiation), and to be preliminary, when tumour localisation is difficult (i.e. brain tumours). In the latter case only zone is marked and CT scans for this area are obtained. The CT examination is performed in a therapeutic position with a complete immobilisation. A CT device is linked on line to VARIS, so the scans are directly sent to the 3D treatment planning system (CadPlan).

To complete treatment planning, individual shielding blocks and tissue compensators are prepared and the patient is resimulated, if necessary. The treatment plan is checked three times and then accepted. Isodose distributions are stored in the computer memory and after two months are transferred to a magnetic tape.

All data regarding the treatment schedule are input into VARIS immediately after treatment plan acceptation. The accelerators are fully controlled by VARIS, so it is not possible to make any mistakes or changes in the treatment parameters and in the total or daily fraction number.

During the first irradiation the quality assurance procedures are performed. The delivered dose and field geometry are checked. The dose is controlled using in vivo dosimetry and the field geometry using a portal imaging system on line (Portal Vision). The accepted error of the delivered entrance dose at our department lies within ±3% of the planned dose. The portal image is compared to a digital image from the simulator. There is no assigned acceptable move of the field. The acceptation of a given field geometry depends on the physician responsible for the patient under the treatment.

Another option provided by VARIS is the storage of the patient's histories, including their follow up, scoring of radiation injuries, treatment results etc. (these data are input by the secretaries) usually completed after treatment. This makes the database very useful for administration and research.

The last VARIS option is the financial and economical management of the radiotherapy department which can be very useful for health care reforms in Poland.

The data flow in our radiotherapy department equipped with a therapeutic line is shown in Figure 4.

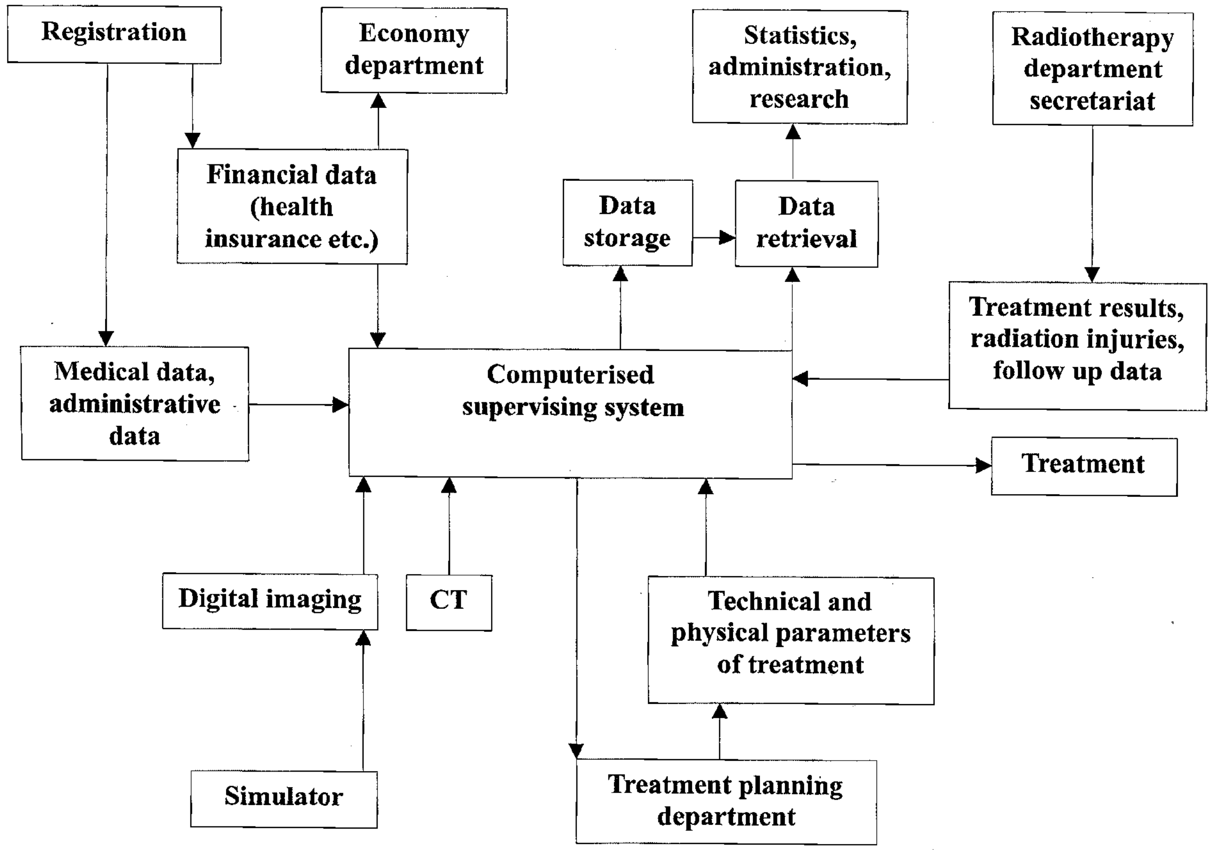

Fig. 4. Data flow inside the radiotherapy department.

Besides data storage in the computer memory, same data are stored in a conventional form, such as simulation X-ray pictures, CT scans, isodose distributions, beam eye views, dose-volume histograms and check-films or prints from the portal imaging system.

All the advantages provided by a modern therapeutic line can be divided into two groups, those beneficial for patients and other advantageous for the medical staff.

The first group includes a precise determination of the target volume, the possibility of steep gradient of the delivered dose what allows to give high dose to the target volume and relatively low dose to normal tissues, the possibility of obtaining a uniform dose distribution in the irradiated volume and high quality of treatment (Aoki et. al., 1987; Brahme 1987; Ishigaki et al., 1983; Kushima and Kono, 1993). These advantages can improve treatment results what is the main gain expected by patient and the doctor. The additional advantage for the patient is a very precise schedule of particular treatment planning steps, which makes the whole process more clear and helps to save more time than in the case of conventional procedures at the radiotherapy department.

As for the advantages for the medical staff the situation is not so clear. No doubt, facilitating treatment schedule and clarifying the work organisation, the medical staff is improved. However, rigid discipline and a large number of particular steps makes the process of treatment planning more difficult and work-time consuming for them. The complex structure of treatment planning and dose delivery as well as complicated quality assurance procedures require high accuracy and care of work in the frame of therapeutic line. However, many QA and double checking steps make all procedures well organised and protect patients and doctors against the risk of malpractice (Aoki et al., 1987).

Our practical experience with therapeutic line and that with reorganised work at the department have enabled us to start radical radiation therapy of two patients per week per physician (all together 15-20 patients/week) in addition to the routine doctor duties at the department (palliative and symptomatic treatment, consultations etc.), which constitutes the upper limit for the staff of eight doctors working full time.

CONCLUSIONS

There are three important points which differentiate the radiation treatment with the use of a full radiotherapy line from that using standard planning equipment and megavoltage units not connected on line.

First, it provides high quality of radiation treatment procedures which is forced by a large number quality assurance procedures and safe data flow. Secondly, the discipline of work becomes very rigorous using the schedules of the VARIS system which is the main change in the work organisation at the department. Thirdly, it is more time consuming, however the treatment becomes safer and more effective for both – the patients and the doctors.

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