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Evaluation of a Telemedicine System for Supporting Thyroid Disease Diagnosis

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Abstract

A telemedicine system connecting Japan and Belarus via a communication satellite and the international ISDN has been in use since February, 1999. Two relational databases, which are essentially the same, are set respectively at Nagasaki University School of Medicine and Gomel Regional Specialized Dispensary in Belarus for management of patients' data and for research including epidemiologic studies. The thyroid ultrasonographic images, microscopic images of cytological findings and other information on patients are sent from Gomel to Nagasaki once a week with diagnoses and comments by physicians at Gomel Regional Specialized Dispensary for cases whom they found difficult to diagnose. Thyroid specialists at Nagasaki University School of Medicine correct the diagnoses, if necessary, on the basis of information from Gomel and send their comments and instuctions to Gomel for improving diagnosis skills of physicians at Gomel. The findings of 330 cases have been sent from Gomel to Nagasaki by September, 2000 since the commencement of the system in February, 1999. Of the 329 cases, thyroid diagnosis was made at Gomel for 261 cases in whom two or more diagnoses were made for 35 cases. As of the end of October, 2000, the Gomel diagnoses have been reviewed for 217 cases and the remaining 112 cases are under review at Gomel. The diagnoses made at Gomel and Nagasaki were in agreement for 110 (50.7%) of 217 cases. Thyroid cancer was diagnosed in 8 cases in whom 6 had been diagnosed at Gomel while the other 2 were diagnosed anew at Nagasaki. The usefulness of the system for improving thyroid diagnosis in Belarus was indicated.

Keywords:

Telemedicine; Diagnosis support; Thyroid disease; Chernobyl accident.

Introduction

A vast area of 25,000 km^2 in Belarus, Russia and Ukraine was contaminated by radioactive substances discharged from the Chernobyl nuclear power plant due to the accident which occurred on 26 April, 1986. A significant increase in childhood thyroid cancer was reported in 1992 [1].

After the accident, several international projects were launched for supporting victims and for investigating the health effects of the accident [2][3][4]. Nagasaki University School of Medicine is a unique medical college that was destroyed by an atomic bomb in 1945, and has subsequently gained invaluable experience in the medical care of atomic bomb survivors as well as information on the health effects of atomic bomb radiation. Nagasaki University School of Medicine has been participating in Japanese governmental and non-governmental projects on the Chernobyl accident and in 1991 the first medical support team was sent to Belarus, Russia and Ukraine to carry out examinations of thyroid disease in children. Since then, many physicians and medical staff have travelled to the three countries from Nagasaki University and provided local medical staff, including physicians, with skills of thyroid examination and methods of systematic medical follow-up including the construction of a computer database for managing the patients' data. The collapse of the Soviet Union at the end of 1991 caused a dramatic change in socio-economic conditions in the three countries and the international support of the three countries to conduct a long follow-up of their Chernobyl victims has become more important. However, it is very difficult for Nagasaki University School of Medicine to provide them

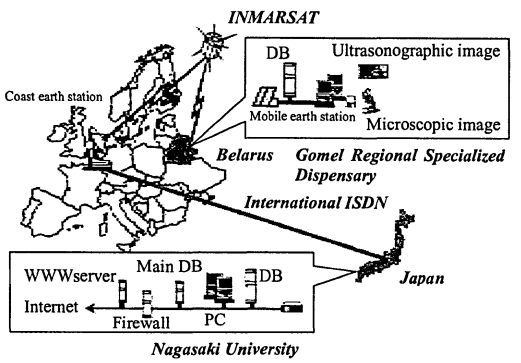

Fig. 1. Structure of the telemedicine system

regularly with physicians and medical staff for lengthy periods. As a solution to these problems, the telemedicine

system was established in February, 1999 by the Nippon Foundation through Sasakawa Memorial Health Foundation and the Japanese Government [5]. The system connects Nagasaki University and Gomel Regional Specialized Dispensary in Belarus because the contamination level of radioactive substances and the incidence of the childhood thyroid cancer were highest in the Gomel region among all of the contaminated areas in the three countries [3].

Materials and Methods

Structure of the telemedicine system

The structure of the telemedicine system is outlined in Fig 1. Two essentially similar databases are set at Nagasaki University School of Medicine and Gomel Regional Specialized Dispensary in Belarus. These databases store the findings of thyroid examinations including thyroid ultrasonographic images and microscopic images of cytological findings, thyroid diagnosis, comments by physicians at Gomel and Nagasaki, and demographic characteristics such as gender and date of birth for each patient. All findings are sent to Nagasaki once a week, in general, for patients showing abnormalities in their thyroid ultrasonographic images. We note that no histological findings are sent to Nagasaki because the histological diagnosis is made after surgery usually conducted at the Thyroid Oncology Center in Minsk. The Gomel Specialized Medical Dispensary, however, is informed of the histological diagnoses later and stores them in the database. Thyroid specialists at Nagasaki University School of Medicine review all of the information sent from Gomel for each patient and correct the given diagnosis if necessary and send the revised diagnosis with comments to Gomel. A one-way connection is currently used between Nagasaki and Gomel to save communication expense. The INMARSAT satellite and the international ISDN are used for connecting Nagasaki and Gomel because no high-speed network such as ISDN is currently available in Belarus: it is, therefore, necessary connect Nagasaki and Gomel via a sattellite and ISDN in western European countries.

Database

Two essentially similar relational databases set at Nagasaki University School of Medicine and Gomel Regional Specialized Dispensary are designed to faciliate data flow management at Gomel Regional Specialized Dispensary and Nagasaki University School of Medicine. Both databases are composed of about 30 tables including those recording date of birth, family history, history of thyroid disease, history of thyroid diseases therapy, results of physical examinations, thyroid ultrasonographic findings and thyroid diagnoses. The databases use ORACLE under NetWare server and Windows NT server at Gomel and Nagasaki, respectively.

Analysis of thyroid ultrasonographic images

Special software, developed by Nagasaki University School of Medicine and Nippon Telegraph and Telephone Co., has been used at Nagasaki to make objective evaluation of thyroid ultrasonographic images. The software faciliates physicians making accurate diagnoses by presenting on the computer display a histogram of the optical density of the ultrasonographic image.

Quality of Images

The system processes three types of images which are specified by the equipment used for examination. The ultrasonographic images are 688x504 pixels, in JPEG format with on average file size of 50 kB. The microscopic images are 1,600x1,200 and 800x600 pixels for normal and enlarged images, respectively, in JPEG format with an average file size of 300 kB. No deterioration has not been observed in the quality of images sent from Gomel, although the quality of some images from Gomel have been low because of the poor cell staining and the low resolution of the ultrasonographic equipment.

Analysis

To evaluate the telemedicine system from the viewpoints of communication technique and medical usefulness, we analyzed the transmission records and medical data sent from Gomel during the period between 2 February, 1999 and 30 September, 2000. We divided this period into four sub-peiods, i.e. Period I was February to June, 1999, Period II was July to November, 1999, Period III was December, 1999 to April, 2000 and Period IV was May to September, 2000, and compared the following factors among the four sub-periods.

Technical aspects

- Proportion of transfer failures via satellite.
- Speed of transfer via satellite.

During the entire period between February, 1999 and September, 2000, file were transmitted 456 times from Gomel and we used FTP logs (Microsoft IIS log) for the analysis. The logs registered file size and transfer duration for each transmission and we defined transfer speed as the ratio of file size to transfer duration.

Medical aspects

- Number of cases sent from Gomel for consultation.
- Degree of agreement in thyroid disease diagnosis made at Gomel and Nagasaki.

The data of 329 patients were sent from Gomel to Nagasaki during the whole period of the study and 217 were reviewed at Nagasaki University School of Medicine while the remaining 112 are under review. We classified the original 33 diagnoses into 10 diagnoses as shown in Table 3 for evaluating the degree of agreement in diagnoses made at Gomel and Nagasaki.

Results

Proportion of transfer failures via satellite

The proportion of transfer failures from Gomel via satellite are shown in Table 1 for each of the four sub-periods.

Table 1. Proportion of failure in transfer via sattelite

Period	Completed Transfer	Failed transfer	(%)	Total
I	135	53	(28.2)	188
II	72	19	(20.9)	91
III	82	8	(8.9)	90
IV	85	2	(2.3)	87
Total	374	82	(18.0)	456

Period I: February-June, 1999; Period II: July-November, 1999; Period III: December, 1999-April, 2000; Period IV: May-September, 2000.

Of 456 transfers from Gomel to Nagasaki, 82 (18.0%) failed and 374 were successful. Table 1 shows that 87.8% of the total failures occurred during the first two periods. Although the cause of this phenomenon is not clear, it may partly be due to the so called initial failure associated with lack of experience in operation.

Speed of transfer via satellite

The average speeds of transfer via satellite are shown in Table 2 for the 374 successful transfers.

Table 2. Average speed of file transfer via satellite

Period	Number of files transferred	Tranfer speed (kbps)	SD
I	135	25.2	11.5
II	72	21.2	13.5
III	82	24.3	11.1
IV	85	21.7	11.7
Total	374	23.4	11.9

Period I: February-June, 1999; Period II: June-November, 1999; Period III: December, 1999-April, 2000; Period IV: May-September, 2000; kbps: kilobits per second; SD: standard deviation.

The file sizes varied between 33 and 1,347 kB and their average was 264 kB. The file size is in effect the size of the images. No significant difference was observed in the mean and standard deviation of the transfer speed among the four periods. The satellite used was INMARSAT B which has an HSD (High Speed Data; 64 kbps) mode. The mean transfer speed of 23.4 kbps was reasonable. We could not use the Internet for file transfer because the domestic network was unstable in Belarus. Although the satellite communicaton costs too much, there is no better choice for stable service.

The number of cases sent from Gomel for consultation

A total of 329 case files were sent from Gomel to Nagasaki for consultation during the 20 months of the study period and the change in the number of cases sent in each sub-period was relatively small as shown in Fig. 2. The files were in general sent every Tuesday afternoon at Gomel local time.

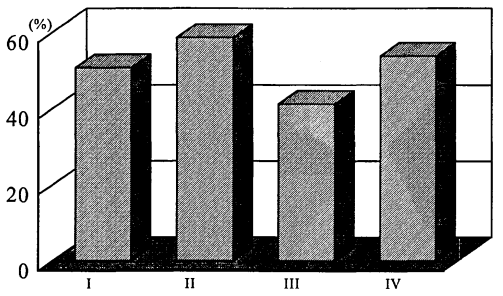

Fig. 2. Number of cases sent from Gomel to Nagasaki for consultation.
Period I: February-June, 1999; Period II: July-November, 1999; Period III: December, 1999-April, 2000; Period IV: May-September, 2000.

Degree of agreement of thyroid disease diagnosis made at Gomel and Nagasaki

Of the 329 case files sent from Gomel to Nagasaki for consultation, a review of the diagnosis at Nagasaki was completed for 217 in whom the diagnosis of 110 (50.7%) cases were in agreement between Gomel and Nagasaki. The diagnoses of 107 (49.3%) cases disagreed between Gomel and Nagasaki. Of the 217 cases diagnosed at both Gomel and Nagasaki, 182 received one thyroid diagnosis at both Gomel and Nagasaki. Cross-classification of the diagnoses at Gomel and Nagasaki are shown in Table 3. The diagnoses made at Gomel which showed a relatively high degree of agreement with those made at Nagasaki were chronic thyroiditis (68.4%), thyroid cyst (87.5%) and thyroid cancer (100%) while a relatively low degree of agreement was observed in diffuse goiter (18.2%) and nodular goiter (37.3%). The physicians at the Gomel Specialized Medical Dispensary usually re-examine the patients if necessary on the basis of the revised diagnoses and comments from Nagasaki, and consult again about the diagnoses by sending additional data if available. Communications between Gomel and Nagasaki will be continued to reach a final diagnosis for each patient.

The degrees of agreement in diagnoses at Gomel and Nagasaki by period are shown in Fig. 3. No significant difference by period was observed in the degrees of agreement of diagnoses made at Gomel and Nagasaki.

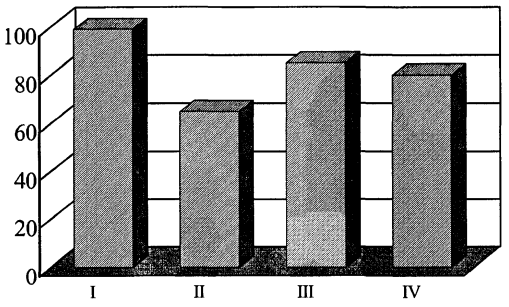

Fig. 3. The degree of agreement by period in diagnoses made at Gomel and Nagasaki.
Period I: February-June, 1999; Period II: July-November, 1999; Period III: December, 1999-April, 2000; Period IV: May-September, 2000.

Discussion

The present study demonstrated the usefulness of the telemedicine system connecting Gomel and Nagasaki for improving thyroid diagnosis at Gomel: two thyroid cancers were diagnosed anew at Nagasaki on the basis of information sent from Gomel. However, no significant increase with time was observed in the degree of agreement of thyroid diagnoses made at Gomel and Nagasaki during the 20 months since the commencement of the system and this may partly be due to the short observation period. Educational support is necessary for physicians as well as medical students in Gomel and we are now participating in implementing the new project, WHO-Sasakawa Healthtelematics Project. In this project, education through the internet will be given to physicians and medical students in Gomel.

No serious problems were observed with respect to the communication technique but the communication expense is the most important factor in maintaining the system. Since the current communication method using a satellite and the international ISDN costs too much to maintain the system, use of another communication line such as the Internet should be considered in the near future.

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Table 3. Cross-classification of thyroid disease diagnoses made at Gomel and Nagasaki

Gomel: Diagnosis	Nagasaki: Normal	Diffuse goiter	Nodular goiter	Chronic thyroiditis	Thyroid adenoma	Adenomatous goiter	Thyroid cyst	Malformation	Thyroid cancer	Other thyroid disorders	Total	Degree of agreement(%)
Diffuse goiter	6	2	1	2							11	18.2
Nodular goiter			25	3	1	11	22			5	67	37.3
Chronic thyroiditis	2		1	13					2	1	19	68.4
Thyroid adenoma			1								1	□
Adenomatous goiter											0	□
Thyroid cyst	1		3			3	56			1	64	87.5
Malformation	1							3			4	75.0
Thyroid cancer									2		2	100.0
Other thyroid disorders	8		2	1			1	1		1	14	7.1
Total	18	2	33	19	1	14	79	4	4	8	182	