# Telepathology in Japan

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A concept of telemedicine has been present from old days, and occasionally the necessity appeared in private and public lives. Recently, with the progression of information technology (IT), telemedicine has been of interest not only to the medical field but also to the government (Fig. 10.1). Telemedicine in Japan is comprised of mainly three factors: one is telehomecare, the second is teleradiology, and the third is telepathology, in which pathological and/or cytological images are transferred from medical institutes to the pathologists in remote institutes by cables (Fig. 10.2). Several causative factors that promote the telepathology in Japan are considered as shown in Fig. 10.3. One of the most important factors is a shortage of diagnostic pathologists. Before addressing telepathology itself, it is important to get a quick overview of diagnostic pathology in Japan. Then characteristic of Japanese telepathology is introduced and discussed from the medical, economical, and technological aspects for next development.

## 10.1 The Present Conditions of Japanese Diagnostic Pathology and the Background of Development of Telepathology

In 2004, there were 1,900 diagnostic pathologists recognized by the Japanese Society of Pathology (JSP), accounting for only 0.7% of the total number of physicians in Japan and showing only minimal growth (Fig. 10.4). This is the most severe doctor shortage of any field in Japan, followed in order by pediatricians, OB/GYNs, and anesthesiologists. As illustrated in Fig. 10.5, the ratio of pathologists to the general population is only about 20% of what it is in the United States. Pathologists have traditionally performed autopsies, biopsies, cytodiagnoses, and intraoperative rapid diagnosis. More recently, pathologists also run clinicopathological conferences (CPCs) for residents and clinicians. The most recent available JSP study shows that Japan's pathologists perform 32,000 autopsies, 5.5 million biopsies, 11 million cytodiagnoses, and 100,000 rapid diagnoses annually. All of these duties are increasing except autopsies year by year (Fig. 10.6), but the pathologists and their works has not been well

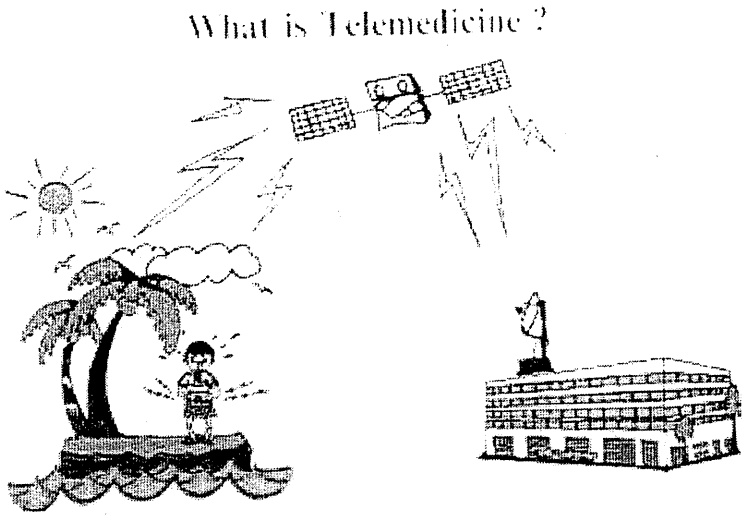


Fig. 10.1. What is telemedicine? The concept of telemedicine has been present in the social life from the old days.

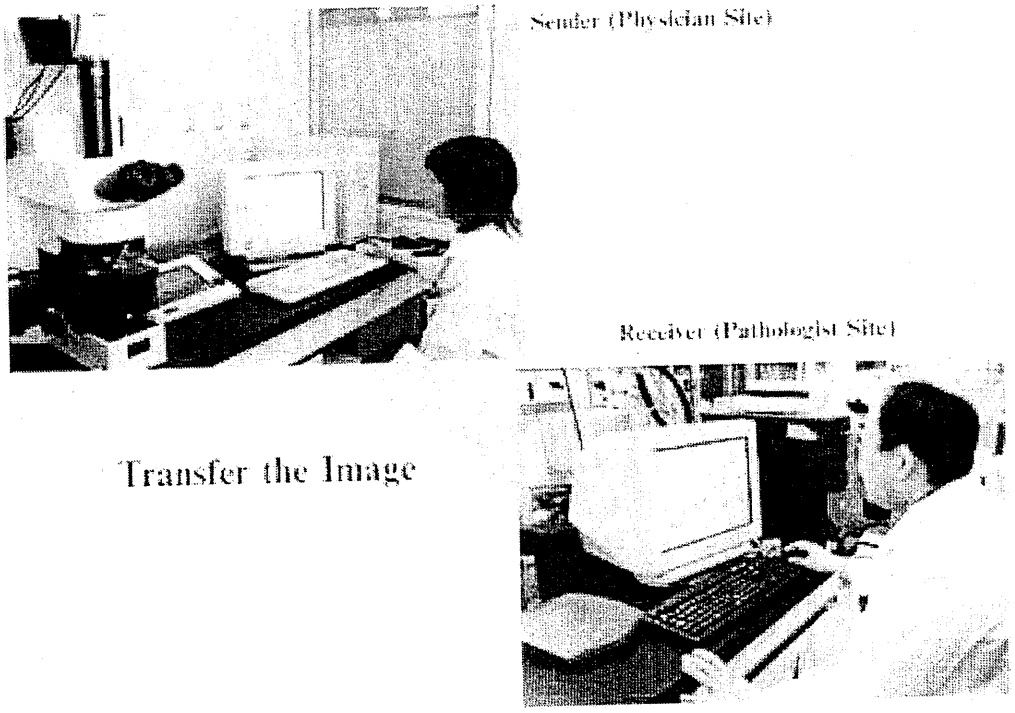


Fig. 10.2. Telepathology system on ISDN. This still image system is now the most spreading type and amounts to 75% of all systems in Japan. The pictures are transferred via ISDN. This system is introduced in 1992 between Tohoku University in Sendai city and Kochisu Kosenmura Hospital in Kosenmura city in costal region, about 30km distance.

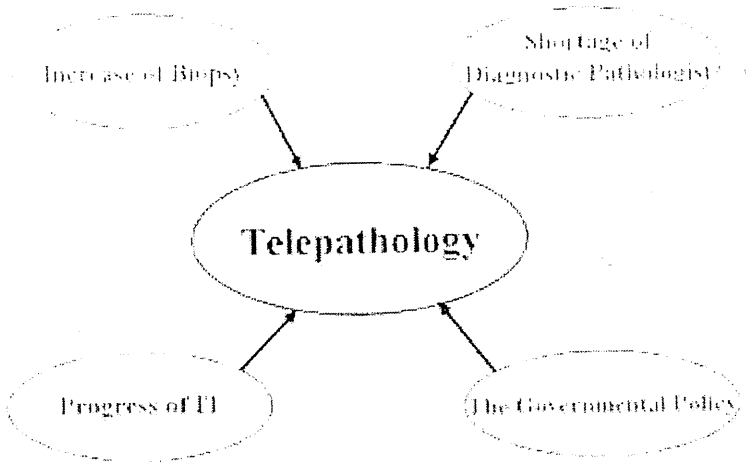


Fig. 10.3. Background of telepathology development. Among many factors that promote telepathology, increase of biopsy samples, shortage of diagnostic pathologists, IT progress, and polices by the Governmental are major factors

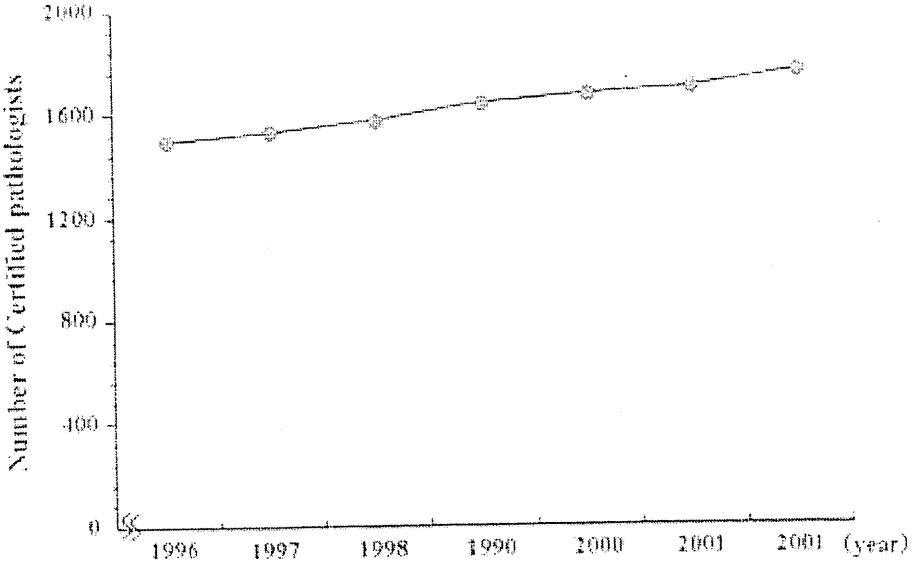


Fig. 10.4. Number of diagnostic pathologists. The number of pathologists increases gradually but still insufficient in Japan

recognized in Japanese society in spite of their important roles (Fig. 10.7). For example, the situation in northern part of Japan (Tohoku Area) is illustrated in Fig. 10.8. Despite having 868 hospitals with 200 or more beds, full-time pathologists are almost exclusively confined to university hospitals and major hospitals in the prefectural capitals, leaving large hospitals in other major cities rarely have full-time pathologists on staff [12–14].

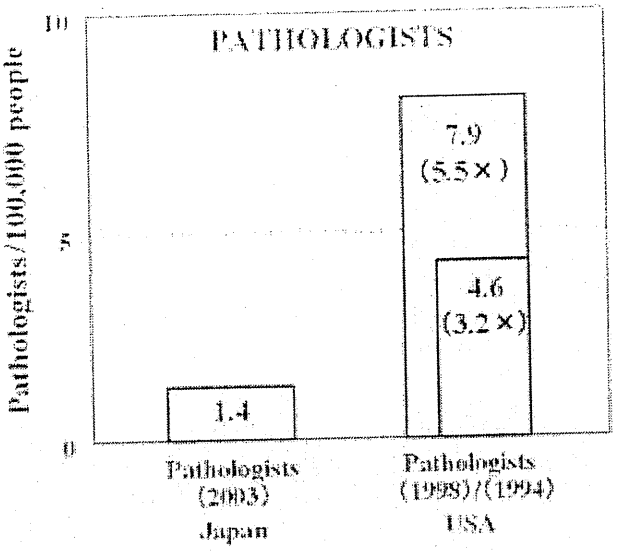


Fig. 10.5. Comparison of pathologist' number between Japan and USA. The numerical ratio of pathologists to the general population is only about 20% compared with one in the USA

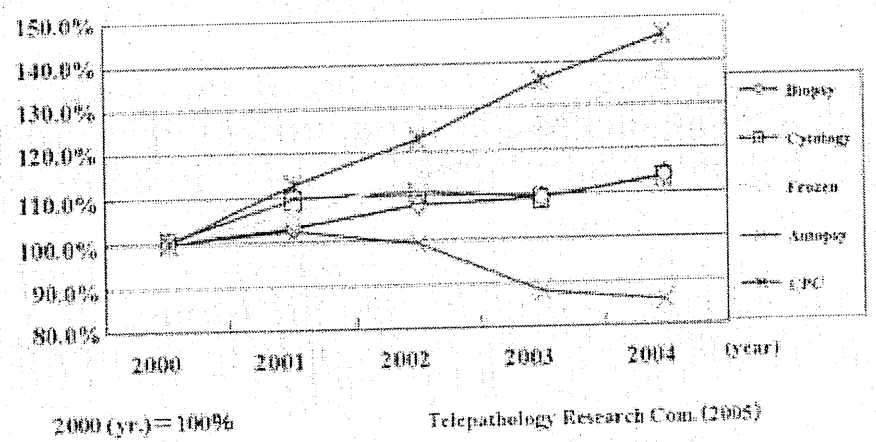


Fig. 10.6. Number of pathological duties in Japan. Pathologist's duties are comprised of biopsy, cytology, frozen rapid diagnosis, autopsy, and clinical pathological conference. The number of duties increases year by year except for autopsy

For this reason, biopsies and cytodiagnoses are often outsourced to university, public, or private laboratories. Generally it takes about several days to a week to get a diagnosis. Under these circumstances, it is impossible to perform intraoperative rapid diagnosis for decision of a next surgical step, especially on a cutoff margin, and has been left to the experience and intuition of the surgeons, as shown in Fig. 10.9. A veteran surgeon's judgment can be accurate relatively, but, in case of new and inexperienced cases or tumors with unclear boundaries, even experienced surgeons hesitate to carry out the operation. Tumors not fully

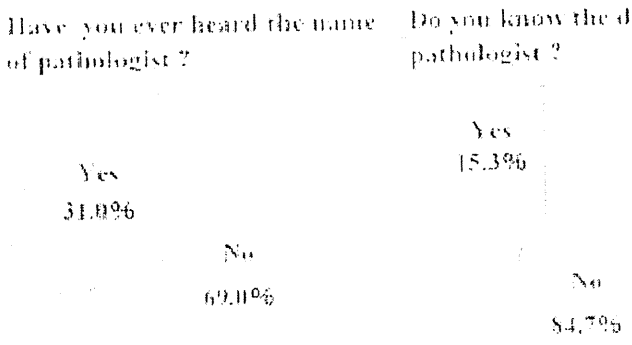


Fig. 10.7. Public consciousness relating pathologist and their duties in Japan. Pathologists and their duties are surprisingly not known publicly in Japan.

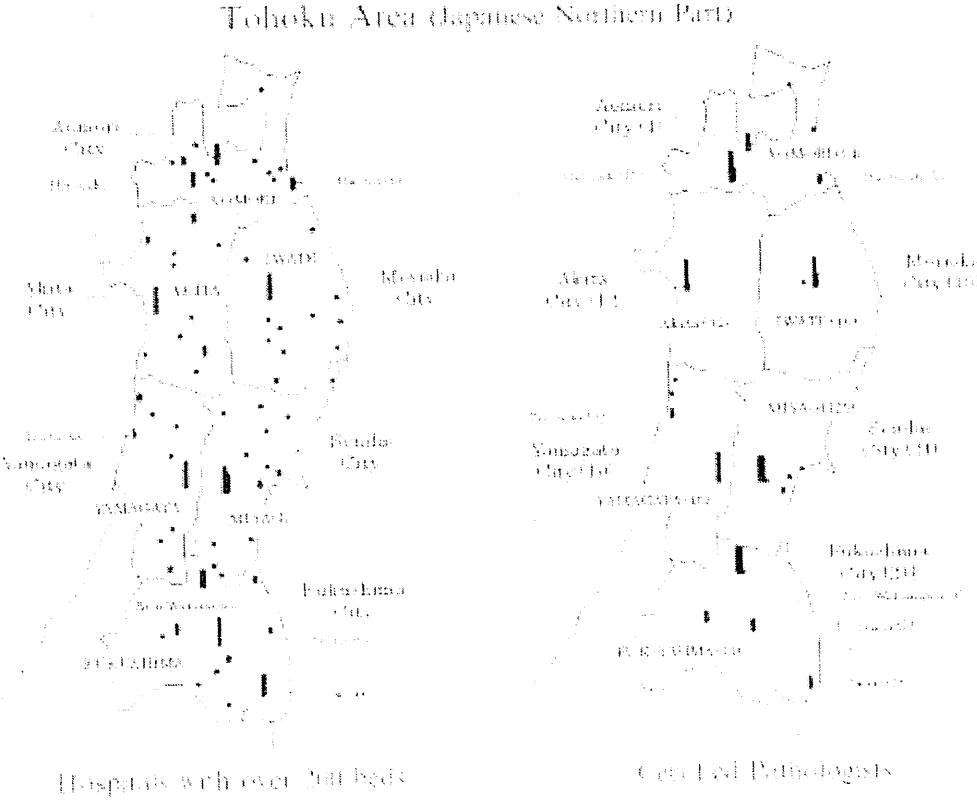


Fig. 10.8. Distribution of hospitals with more than 300 beds (left) and hospitals with core lab pathologists (right). The number of pathologists is very small in southern part of Japan and most of all converge into universities and large hospitals or large cities.

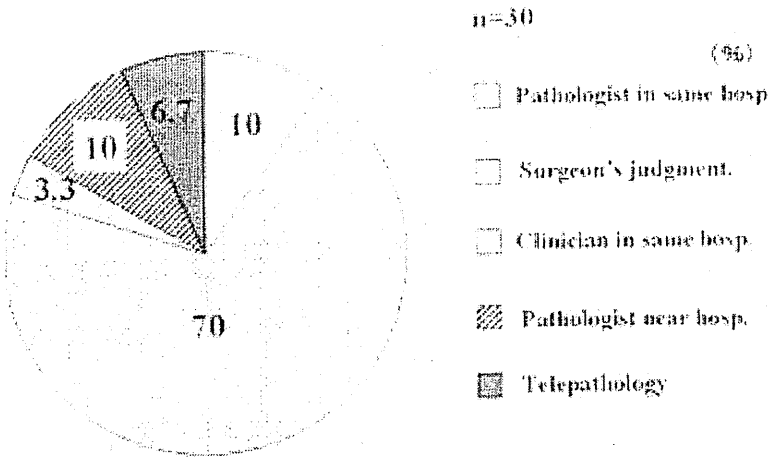


Fig. 10.9. In case of necessity who diagnoses rapidly? In the hospital without pathologists, quick decision related to next step in operation is dependent on surgeon's experience and intuition

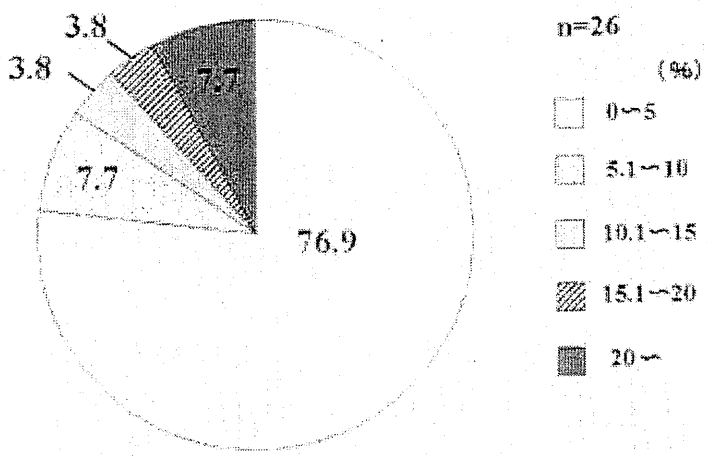


Fig. 10.10. The ratio of intraoperative rapid diagnosis. Ratio of cases requiring intraoperative diagnosis to all operations is 5% (surgeons' comment)

excised will surely recur. From a survey of surgeons with 15 or more years of experience, it was revealed that 3–10% of past cases (5% on average) require the intraoperative rapid diagnosis (Fig. 10.10).

## 10.2 The History of IT and Telepathology in Japan

The background of telepathology development in Japan is shown in Fig. 10.3. Among them, most noticeable and influential fields in development of information technologies are the spread of the Internet. Microscopic imaging, for example,

has seen enormous advances with the digitization of images, and it has become possible to quickly and easily transfer images to distant locations. However, pathologists who diagnose by optical microscopy systems have felt a great deal of resistance to image-only diagnosis, more than troublesome, and not sufficiently developed systems. Indeed, early telepathology images were vastly inferior to microscopic images and had a risk of misdiagnoses. An additional problem was that it took a longer time to diagnose with still images compared with optical microscopy, and the frustration occurred to both clinicians and diagnosticians. For these reasons, many pathologists were not enthusiastic about the practicality of telepathology.

In 1982, what was probably the world's first telepathology in color experiment was carried out by Dr. Hiroshi Sakaguchi of Keio University in Tokyo [7]. This test linked the university to a hospital in Hachioji (also in Tokyo). A quarter century after this experiment using analog phone lines, fiber optics and digital images are becoming the norm. Almost a decade later, at the 23rd Japan Medical Congress in 1991, the Kyoto Prefectural University of Medicine linked with Yosanoumi Hospital (on the Japan Sea side) to demonstrate telepathology, which was subsequently added to the university's normal operations. The National Cancer Center also hooked up its main hospital in Tsukiji, Tokyo, with Hospital East in Kashiwa, Chiba, and Yamagata University connected its Faculty of Medicine with the University Hospital via optical fiber. The following year, at the 81st meeting of the ISP, Tohoku University was linked with Sendai City Hospital through optical fibers for a video (motion picture) telepathology experiment [11]. At this stage, each facility was researching and developing its own telepathology formats.

## 10.3 Recent Governmental Policy and Activity to Telepathology

Recently, the prevalence of telepathology has been accelerating. Among the changing societal factors for the development of telepathology are continuing the condition of shortage of diagnostic pathologists (Fig. 10.4), the prevalence of the Internet, and the societal shift to computerization in social activity, including medical filed, medical accidents, and patients' increasing desire for a second opinion. In addition, the establishment of a Telemedicine Research Committee by the Health and Welfare Ministry (the current Ministry of Health, Labor, and Welfare, or MLHW) cannot be ignored. The research group, initially headed by Dr. Shigekoto Kaihara of the University of Tokyo (currently dean of the graduate school of the International University of Health and Welfare), researched homecare, teleradiology, and telepathology. Another significant event in the history of telepathology came in 2000, when telepathology was

included as an insured health-care service. This was followed by the expansion of diagnostic facilities in 2003. The MLHW's official acceptance of telepathology represented a change from its previous policy of recognizing only direct, face-to-face medicine, and this was a major impetus for the spread of telepathology. The telepathology research committee supported by MLHW defined that telepathology is to do something related to a medical action associated with medical practice, education, and research from the distant area on the basis of information of macro- and microscopical images.

Although some aspects of telepathology such as added fees required for equipment and telecommunication are still unclear, recent surveys have shown that the usage of telepathology is steadily, although gradually, increasing. In 2004, 55 facilities were linked with 120 hospitals and clinics to provide telepathological services for nearly 2,600 cases (Fig. 10.11). Apart from the telemedicine research group supported by the government, pathologists, physicians, cytologists, vendor, and developer of private company established the group named the "Japanese Research Society of Telepathology and Telepathology Informatics" (JRST-TI) in 2000, had made a guideline for Japanese usage in 2003 [19], and changed the name to the "Japanese Research Society of Telepathology Virtual Microscopy" (JRST & VM), now examining a guideline for a telecytology and application for virtual microscopy.

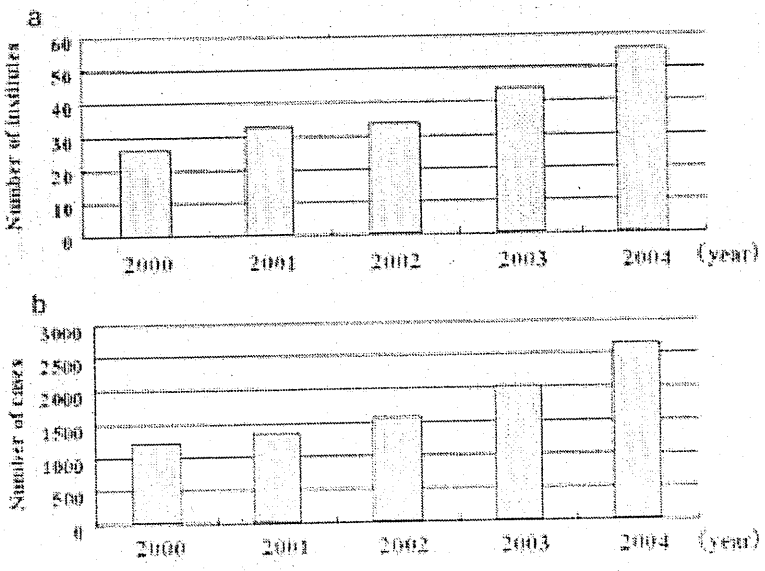


Fig. 10.11. Number of institutes practicing telepathology and the number of cases. Institutes and number of cases practicing telepathology increase gradually year by year

## 10.4
## The Purpose of Japanese Telepathology, Especially Intraoperative Rapid Diagnosis

In Europe and the United States, telepathology is used widely in consultations, but in Japan, it is overwhelmingly used for intraoperative rapid diagnosis (Fig. 10.12). One of the reasons for this difference is that telepathology in Japan began from rapid diagnosis under the auspices of the MLHW. This intensive government support for telepathology is characteristic and may be different from other countries in the world. The other reason for development is the latent clinical desire for rapid diagnosis for telepathology. In the future, because of patients' increased consciousness in medicine and a spate of recent medical lawsuits, it seems likely that telepathology will be used increasingly in consultations and second opinions and other purposes relating images.

Generally, rapid telepathological diagnosis is used for diagnosis of malignant tumors and metastasis, and for confirmation of cutoff margin whether tumor is still left or not (Fig. 10.13) [23]. I, here, introduce two surgical cases, one is a need for a further resection and the other is finished without additional excision in a short time owing to diagnosis of telepathology (Figs. 10.14 and 10.15). These are the large benefits of telepathology viewing from the point of medical and economical aspects.

In the past, the MLHW requested a study of the relationship between rapid diagnosis and the recurrence of tumors. In other words, the ministry wanted to know with what frequency cancers recurred, as rapid diagnosis had not been performed. When it became clear that there was no hope of cooperation from

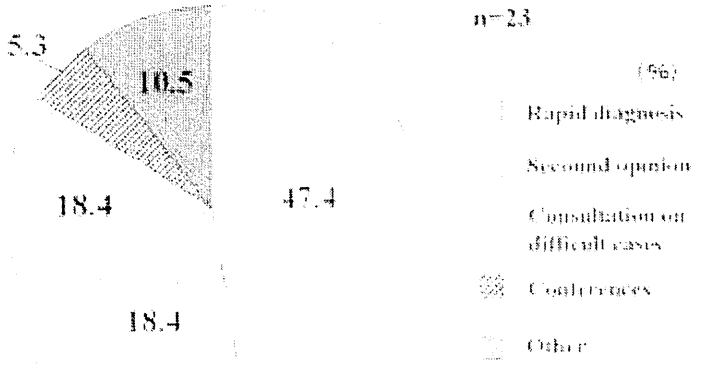


Fig. 10.12. The purpose of telepathology. The telepathology is used for intraoperative rapid diagnosis, second opinion, consultation, and pathological and clinical pathology conference

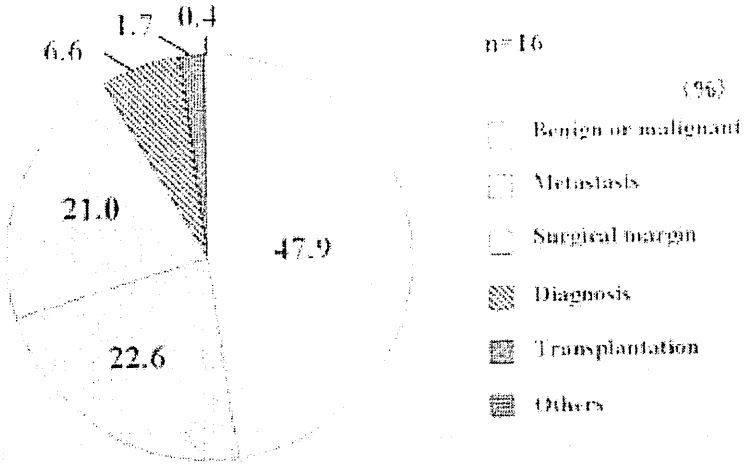


Fig. 10.13. The purpose of intraoperative rapid diagnosis. Diagnosis whether the tumor is malignant or benign, confirmation of metastasis, and cutoff margin are major purposes of intraoperative rapid diagnosis for decision of next step quickly

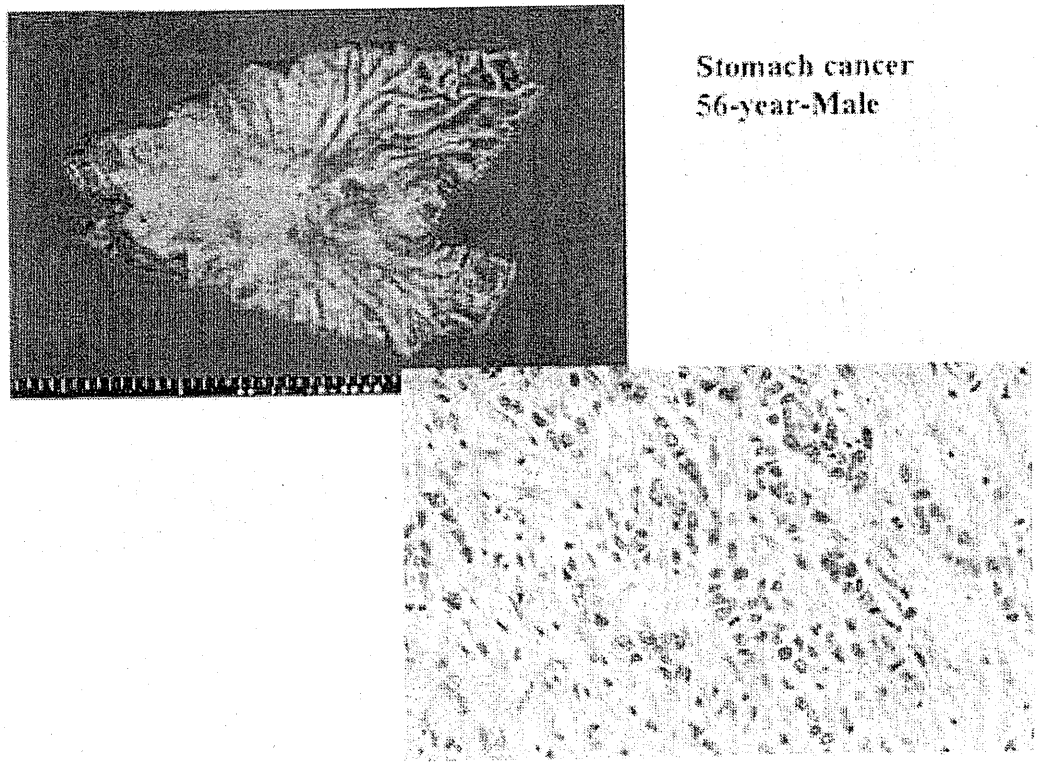


Fig. 10.14. Intraoperative rapid diagnosis performed in telepathology. The patient was a 56-year-old male. He underwent the operation for stomach cancer. Intraoperative rapid diagnosis in telepathology revealed the cancer residue in cutoff margin at esophago-cardiac junction, and further excision was performed

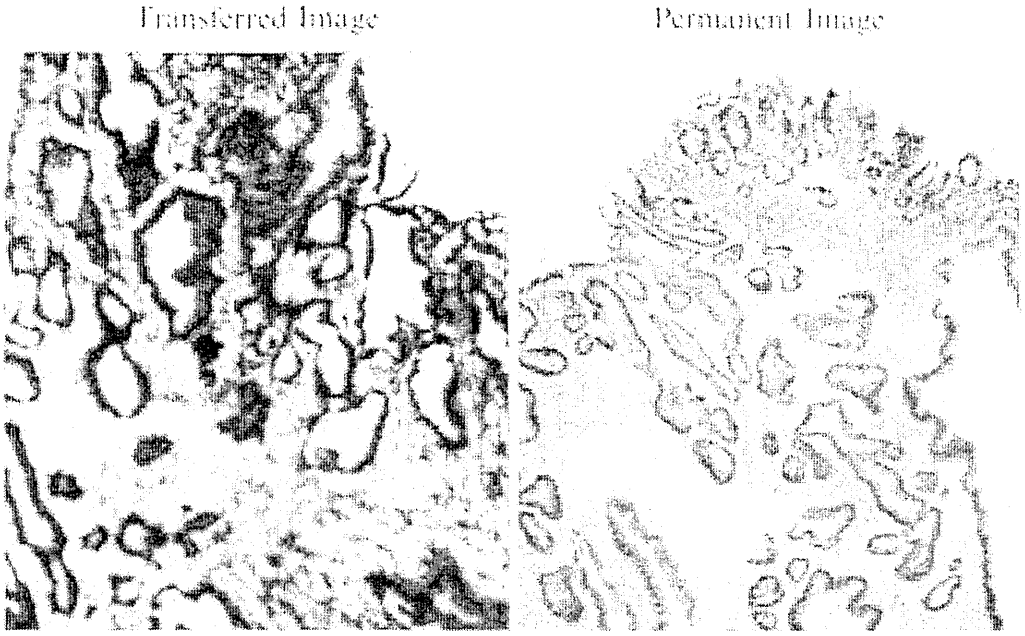


Fig. 10.15. Intraoperative rapid diagnosis by telepathology. The patient was a 66-year-old female. She underwent the operation for carcinoma of common bile duct. Intraoperative quick diagnosis by telepathology showed that the tumor was adenoma, not malignancy, against preoperative clinical diagnosis. Operation was finished without further wide resection. She is well now

medical practitioners, the ministry asked, instead, for a report of the percentage of surgeons' requests for rapid diagnosis. Improperly or incompletely removed tumors always recur, endangering patient's lives. But that is not all. Recurrence obviously places enormous physical and emotional burdens on patients and their families and also wastes valuable medical time and resources. Studies have shown that initial operations on gastrointestinal cancers like stomach and colon cancer cost about $18,000 (Table 10.1) and that subsequent therapies in the case of recurrence are never less expensive. On the contrary, Tanita (Japanese respiratory surgeon) reports that using video-assisted thoracoscopic surgery (VATS) for a rapid lung cancer diagnosis and followed by the excision of the same pathological lesion, if necessary, lead to a saving of $4500 compared with performing two separate surgeries [16]. From these facts, it is clear that the pathological intraoperative rapid diagnosis not only improves in patients' prognosis but also brings an economical saving as intensively desired by the MLHW.

**Table 10.1.** Payment for hospitalization of carcinoma operation and the recurrence

| Age (year) (Sex) | Disease (result) | Operating mood | Hospital stay (months) | Hospital fee (S) |
|---|---|---|---|---|
| 67 (male) | Colon cancer | Colectomy | 2 | 11,300 |
| | Recurrence (dead: after 3 years) | Ope (–) | 3 | 18,253 |
| 86 (male) | Stomach cancer | Total gastorectomy | 1 | 19,600 |
| | Recurrence (dead: after 1 year) | Ope (–) | 2 | 9282 |
| 63 (male) | Stomach cancer | Total gastorectomy | 2 | 23,905 |
| | Recurrence (dead: after 2 years) | Ope (–) | 1 | 10,124 |

Charge to be paid is not so different between the first operation and the recurrence, that is to say, the recurrence of tumor brings a large economical burden as well as time, labor, and patient's life

## 10.5 Development of Infrastructure and Telepathology Systems in Japan

Telepathology systems require both hardware and software. Hardware is mainly IT dependent, including communications infrastructure, digital cameras, computers, and microscopes. Software applications provide the tools to effectively use this infrastructure. In its infancy, telepathology relied entirely on analog phone lines. Integrated Services Digital Network (ISDN) subsequently became available, then multiple ISDN lines were bundled together, and most recently the field has begun to move to asymmetric digital subscriber lines (ADSL) and optical fiber cable. These developments have vastly increased the amount of transferable data (Fig. 10.16). Mobile telepathology is also being developed. Although it initially relied on communications satellites, mobile telepathology benefits from the technological advances seen, for example, in mobile phones, which are now able to receive image data on the move. However, issues including image quality, operability, and internationalization remain unresolved.

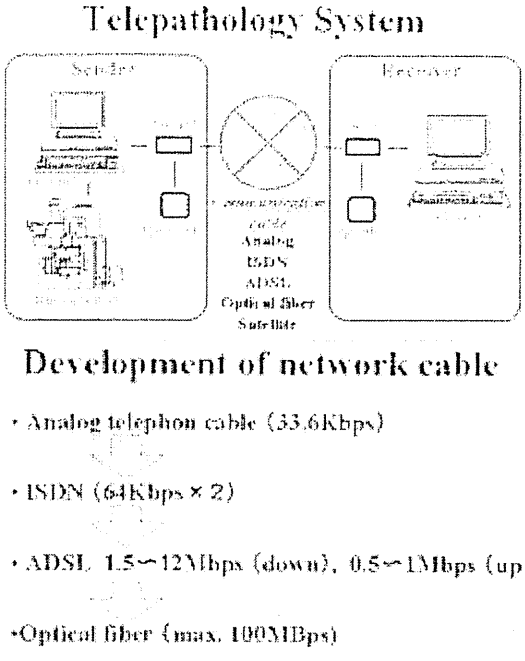


Fig. 10.16. Telepathology system (*upper*) and network development (*lower*). In short time, network cable has developed from analog cable through ISDN, ADSL, to recent optical fiber

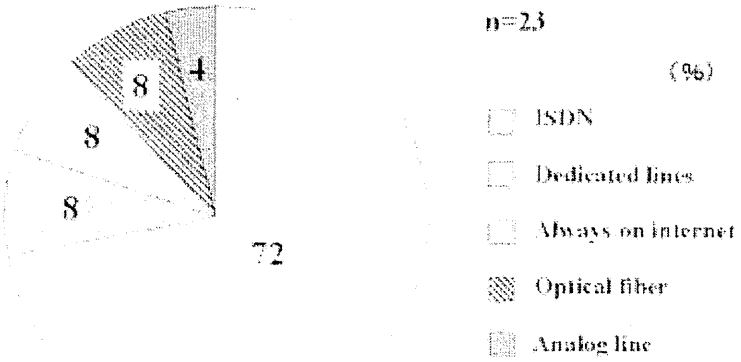


Fig. 10.17. The infrastructural cables used for telepathology (2002). Although the ISDN was most utilized cable for telepathology in 2002, the broadband (ADSL and optical fiber) may take place now, including still, videos and virtual pictures in a short time

As shown in Fig. 10.17, rather old data, the overwhelming majority of telepathology systems rely on the transfer of still images over ISDN lines. Although in most cases the pathologists on diagnostic site is able to select the field by remote control, some systems still require the physician who requests the diagnosis on sending site to operate system by himself. Analog telepathology formats using

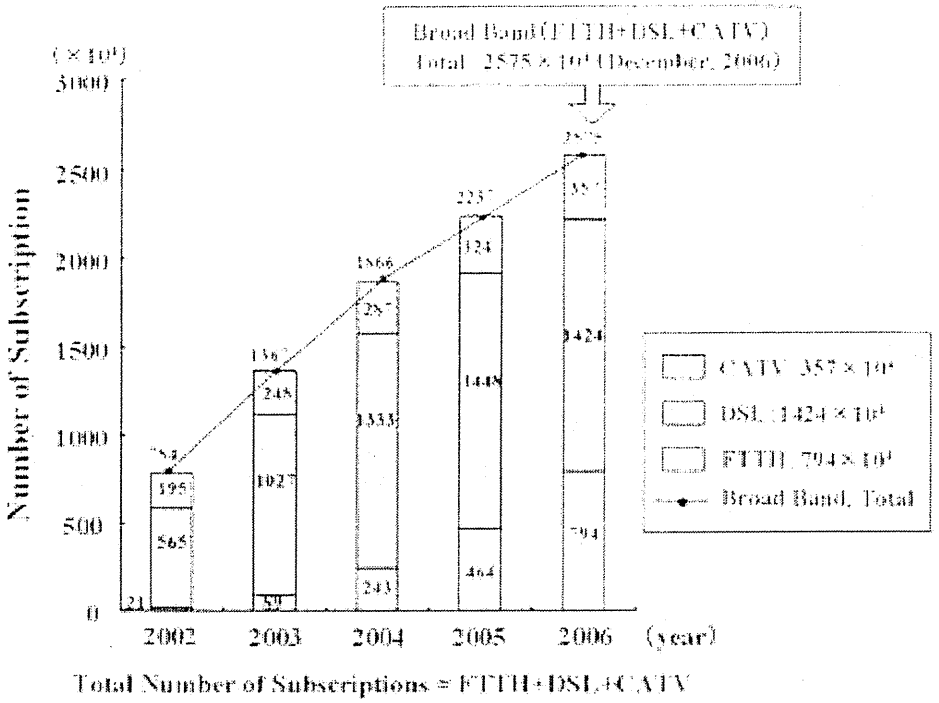


Fig. 10.18. Number of broadband subscriptions. Number of subscriptions of broadband including CATV, DSL, and FTTH increases rapidly in Japan by the aid of the Japanese government

telephone lines still exist, but they are disappearing rapidly in Japan. In their places, formats using broadband Internet connections (ADSL and optical fiber) have appeared, and, in the context of Japan's e-Japan Strategy and u-Japan Policy, expectations are high for their future progress. At the end of 2006, about 26 million families subscribed for broadband usage (Fig. 10.18). In particular, video telepathology via optical fiber allows the diagnostician to select the viewing fields freely and operate the equipment by themselves, meaning that the observation process is nearly identical to checking specimens under a conventional microscope directly (Fig. 10.19). This video telepathology has brought astonishing effect on saving time for intraoperative rapid diagnosis, as shown in Table 10.2 [15].

## 10.6 Telepathology Applications in Medical Field

As noted earlier, telepathology is currently being used in intraoperative rapid diagnosis, provision of second opinions, consultations, and conferences (Fig. 10.12). Rapid diagnosis employs telepathology to diagnose whether malignancy or not.

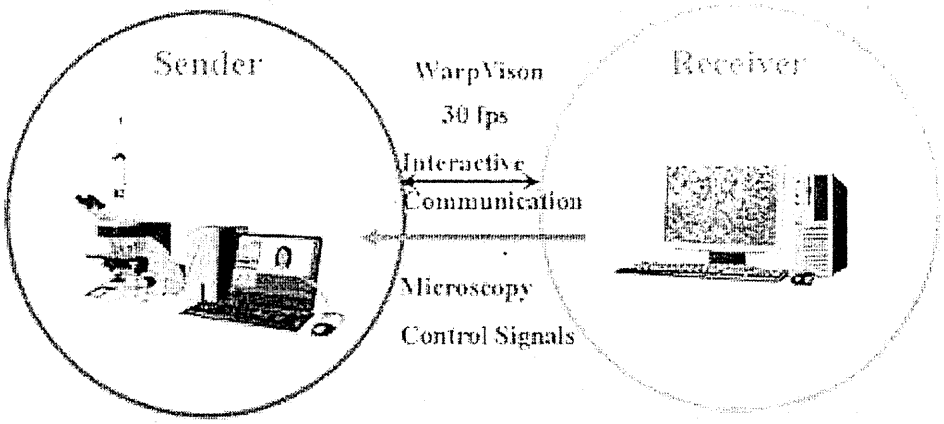


Fig. 10.19. Video telepathology system. Selecting the visual field and focusing are operated by observer freely, as well as direct optical microscopy using remote controller via optical fiber

**Table 10.2.** Intraoperative rapid diagnosis by video image via optical fiber

| Telepathology via video system (11.1.2004 to 1.15.2005) | | | | |
|---|---|---|---|---|
| No. | Organ | Sample Size (mm) | Time (min) | Diagnosis |
| 1 | Margin, pancreas | 20 × 15 | 3 | No carcinoma infiltration |
| 2 | Margin, stomach | 8 × 20 | 3 | No carcinoma infiltration |
| 3 | Margin, stomach | 5 × 35 | 6 | No carcinoma infiltration |
| 4 | Margin, stomach | 10 × 7 | 6 | No carcinoma infiltration |
| 5 | Margin, stomach | 12 × 8 | 4 | No carcinoma infiltration |
| 6 | Margin, duodenum margin, esophagus | 3 × 85 × 9 | 43 | No carcinoma infiltration |
| 7 | Margin, stomach | 5 × 10 | 7 | No carcinoma infiltration |
| 8 | Margin, pancreas | 20 × 15 | 3 | No carcinoma infiltration |

Mean time—4.3 min/slide

The pathologist can freely select the visual field as well as adjusting the focus of the slides glass on the table of optical microscopy from the remote institute as if seeing the optical microscopy directly. Mean time of intraoperative rapid diagnosis by video image is accomplished in 4.4 min/case, very short compared with still image in 35 min/case

classify tumors, confirm metastasis, and decide the surgical margin. Second opinions are required for the reconfirmation of borderline diagnostic tumors and for therapeutic selection from various ones. Furthermore, it appears that rather than extremely difficult cases, telepathology is used more frequently to determine whether a gastric tissue biopsy is group III or IV — in other words, whether or not an immediate operation is necessary. Telepathology is also becoming increasingly popular for breast cancer diagnosis [3,8] and second opinions from the point of cosmetic therapy as well as medical one.

Several facilities have CPCs by teleconferencing system, for example, Tokyo Medical University's internal CPC between medical school in Shinjyuku and Hachoji Hospital, and Iwate Medical University's conferences for interns with the Kuji Prefectural Hospital in the Sanriku area (on sea side) over a steep mountain, using the teleconferencing technologies. We had a teleconference linking 301 hospitals in Beijing in China over the Internet (Fig. 10.20) [22] and also had a video teleconference with Ryukyus University in Okinawa, the most southern

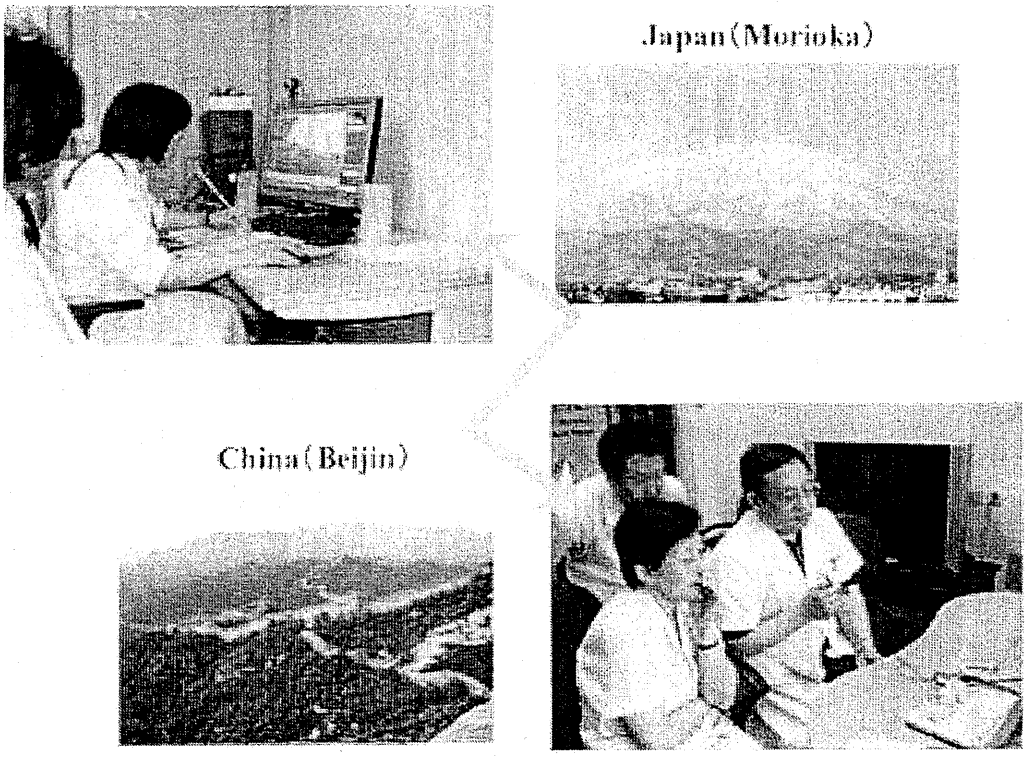


Fig. 10.20. International telepathology conference. The conference is held in September 2006 between Japan (Morioka) and China (Beijing), via cables of optical fiber at Japan site and ADSL at China site

islands area in Japan, about 2,000 km away from our IWATE Medical University, via optical fiber.

Telepathology is applied for community medicine and for the treatments in many fields. One of them is for operation of pulmonary cancer [1], associated with smoking, which is increasing in number (women in particular). Another is transplant medicine [4,5], for which there are not enough specialists in Japan. Second opinions are often sought regarding surgical procedure in hemopathies requiring emergency treatment, and breast cancer or prostatic cancer. Recently, the telecytology has also been paid attention via Internet or optical fiber [24,25]. For now, suffice it to say that telepathology is effective in many situations and offers outstanding medical and economic benefits.

## 10.7 The Telepathology System in Future

### 10.7.1 The Government Strategy to Telepathology

As it is impossible to increase the number of pathologists rapidly in the near future in Japan, telepathology for elevation of a medical level is necessary. Japan's e-Japan Strategy and u-Japan Policy assure that the nation's optical fiber infrastructure will continue to grow. Given this, discussions on the future of telepathology can be predicated on the existence of increasingly universal broadband telecommunications. It seems likely that, depending on the cable infrastructure of optical fiber, telepathology using video (motion) and/or many still images may well become the norm. On the while, virtual microscopy, in another word, the digital microscopy, has been increasingly introduced recently in Japan, because the MLHW endeavor to promote "the cancer control strategy" in which digital microscopy is recommended for establishing the consultation system via web servers (Fig. 10.21). MLHW established the new group for standardizing the medical levels, including diagnoses and therapeutics. By the governmental quick action, about 100 medical institutes introduced the digital microscopy in only half a year. Probably the number of digital microscopes in Japan is second next to USA in the world. This digital microscope is also available for the education such as histological and pathological studies and already used in several medical schools, which has brought the discussion, in medical education, whether traditional optical microscopy is necessary or not in the practical training for medical students [2,17,18]. However, the digital microscope now requires a long time to load the images for using intraoperative rapid diagnosis.

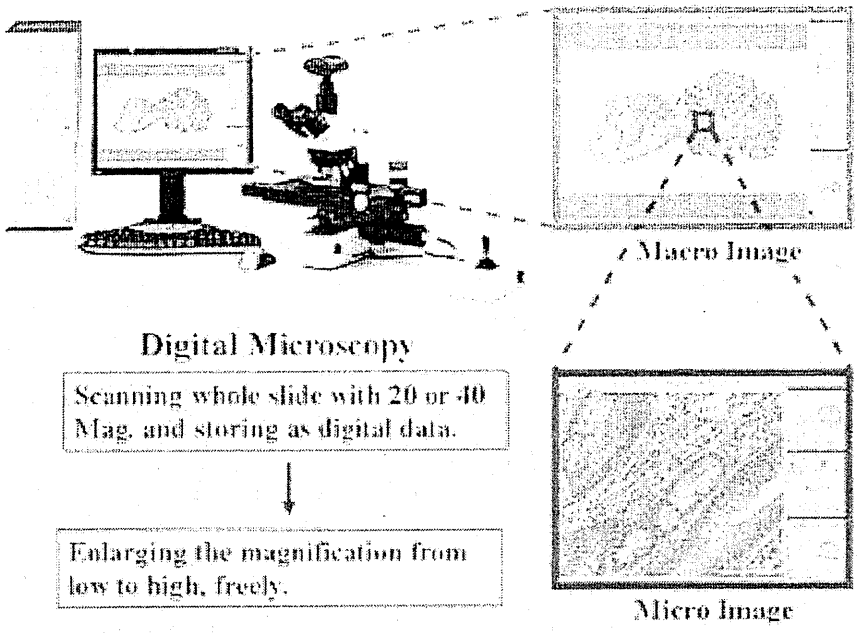


Fig. 10.21. Digital microscopy system. The system of digital microscopy, called scan microscopy, is now broadly introduced in Japan for diagnostic consultation and education, especially in the field of "cancer control strategy," promoted by the Japanese government

Mobile technology has made wireless pathological diagnosis possible and eventually should be able to transfer images between the Japanese mainland and outlying islands, as well as internationally. But for a small volume of transferable capacity, mobile telepathology is not practical but still in the experimental stage [21]. Internet-based telepathology serves as a stopgap in areas where optical fiber is still not available, but the use of the Internet raises security concerns. Internet-based telepathology includes both the use of e-mail file attachments and the server-based file transfer [6].

Three kinds of telepathology systems are considerable in Japan: first, most popular system is using e-mail with attachment of the figures for international communication as well as for domestic area without broadband cables; the second is video (motion) images telepathology system by broadband cables such as ADSL and optical fiber; and the last is digital microscope, using uploaded images in web server for consultation and/or second opinion, and also for the medical education. When broadband Internet becomes ubiquitous, it would be ideal for video and uploaded images to be toggled with a single click so that both could be used in rapid diagnosis or consultations for necessity (Fig. 10.22).

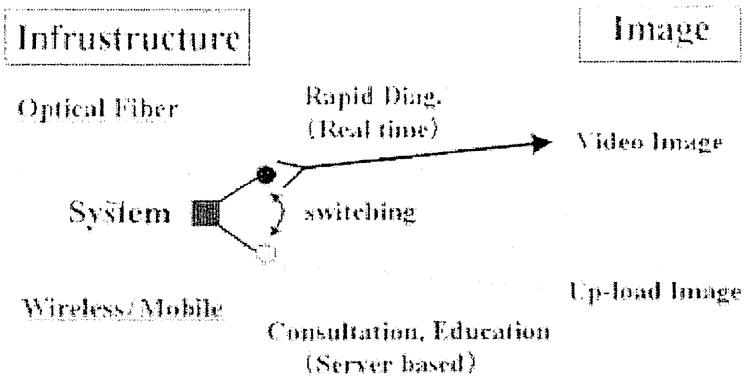


Fig. 10.22. Combination system of video and digital images. The combination telepathology system is applicable for both intraoperative rapid diagnosis and consultation and/or education

### 10.7.2
### Technological Development of DVDs and the Imaging Compression Technology

As broadband image transfer becomes possible, the development of equipment to send and save massive amounts of data becomes necessary. As the number of pixels in digital images increases, their precision improves. However, these higher-quality images also require greater storage space; especially virtual slides, a recent development in pathological imaging, are particularly large. Even if a few slides could be saved on, as the number of cases increases, much higher capacity storage also becomes necessary. Recent technologies allow these images to be compressed, saved, and decompressed again later for use. Hopefully, these compression technologies will continue to develop and evolve day by day.

## 10.8
## Problems Relating the Prevalence of Telepathology in Japan

Telepathology in Japan began as an expedient way to use IT to compensate for the shortage of diagnostic pathologists. In this sense, the progress of telepathology has been quite spectacular as Japan's IT strategy. It appears that if only the number of diagnostic pathologists would increase, telepathology's original goal could be reached. However, it is highly unlikely that such an increase will happen anytime soon. Furthermore, telepathology reveals the superior effect more than we expected in early stage, by which excellent images are useful not only for diagnosis but also for image storage as digital memory in computer without color fade, saving spaces of slide glass and also using the images at any

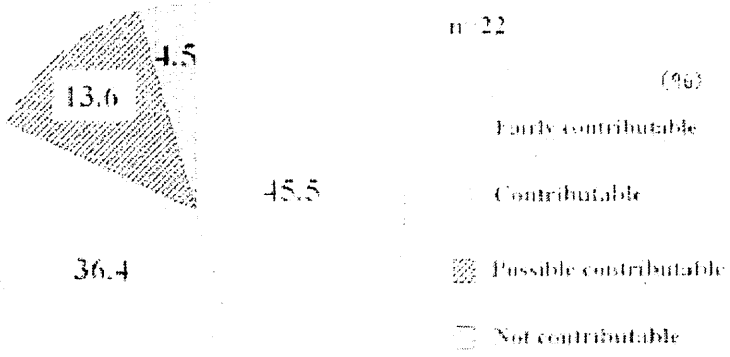


Fig. 10.23. Evaluation of telepathology for community medicine by doctors. More than 95% of surgeons consider that the telepathology is contributable on community medicine

time easily without wasting time, transferring by cable, or transporting by USB flash memories.

For the forefront of medicine, frequent occurrence of medical lawsuits, electronic medical records promoted by national policies, and the image based e-learning [9] and/or researches [20], telepathology is poised for continued growth and development, with the improvement of the related infrastructure and hardware. Figure 10.23 represents the surgeon's comments related to the role of telepathology on community medicine [10]. More than 95% surgeons consider that telepathology is contributable or community medicine and want to use it, if economical problem is settled.

To contribute the best to the medical field, it is imperative that the governmental, academic, and industrial sectors work together to form a shared future vision.

## 10.9 Summary

- Telemedicine, developed based on the progress of IT, mainly comprises telehomecare, teleradiology, and telepathology.
- Telepathology in Japan begun in 1990s and developed because of shortage of pathologist, remarkable development of information technology, and relaxation of law, and by the governmental policy on IT. Now the number of institutes practicing telepathology amounts to 53 and cases are 2,600 in 1 year.
- The purposes of telepathology are intraoperative rapid diagnosis, consultation and/or second opinion, clinical pathological conference, etc.; the most urgent requirement being intraoperative rapid diagnosis, which is useful for