 特 集

Diagnostic partnership via telepathology

—An international project to develop high standard diagnosis and quality assurance in diagnostic cytology by telecommunication—

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Thank you very much for your very kind invitation to present a new project and some ideas concerning TP (telepathology) at this meeting. It is a great honour for me as an pathologist leading a small private institute in a small medieval town in a remote and very peaceful countryside, Aurich, Germany (Fig. 1).

I want to speak about DIAGAID (Fig. 2) because this project is reflecting the possibilities as well as the limits of telepathology and telecytology^{1~3)}. DIAGAID is a partnership in diagnostic aid founded at the Vth European congress on Telepathology 2000 in Aurich at a round table discussion between participants of developed and developing countries (Fig. 3). There is no sharp delineation between developing and developed countries because in some senses we are always living in a developing society. The aim of this project is the exchange and communication in respect to diagnostic help, experience, quality control and establishing personal and institutional networks in medical care via telepathology. Development of medical networks seems to be necessary if we look at

Fig. 1

Fig. 2

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Fig. 3

Medical Quality in developing and developed countries

Country mortality	Live expectation a.	infant mortality ‰
Laos	52,2	102
Thailand	69,5	45
Germany	76,3	6
Austria	78	6
Japan	80,6	3,6

Fig. 4

Medical Support in developing and developed countries

Country	Inhabitants mio	Pathologists
Laos	5	2
Thailand	65	250
Germany	80	1500
Austria	7	250
Japan	125,6	1689

Fig. 5

Requirements

Center	Image Quality minimum	number of Images	Consultation time	charge
AFIP	750 x 500 JPEG	5 - 10	24 h.	50 \$
UICC	800 x 600 JPEG	5 - 10	3 d.	charge free
TPC.PC	800 x 600 JPEG	5 - 10	n.d.	charge free

Fig. 6

the difference in life expectancy and infants mortality in different countries (Fig. 4). Medical support may be documented in the figures of physicians in relation to the number of inhabitants and especially in the number of pathologists (Fig. 5). There are some countries in Asia also in Africa which have a lack of medical facilities and of medical manpower. In the past some consultation centers have been established, AFIP⁴⁾, UICC⁵⁾ etc, which are offering diagnostic helps in difficult cases, but they are working on a very high sophisticated level, which cannot be obtained in developing countries and which are not be required for basic medical care (Fig. 6).

We can divide telepathology technique in high end and low end solution, ranging in dynamic system to

static one using 3-chip to web cam running on broadband to analogue networks³⁾ (Fig. 7). One basic principle of a technical solution is to find out this overlapping area of diagnostic accuracy and financial possibility. There may be two ways to find the optimal solution (Fig. 8), one copying conventional slide handling with continuous reading which demands a development of new systems, with remote controlled microscope and with routine microscope, virtual slide production. The other way is the cheaper one : constructing a modular system out of existing components which implicates a new method of slide reading by looking at fragmented details. It seems to be the adequate way for consultation pathology. The technical design is very simple. We may use one camera for

Fig. 7

Fig. 8

Fig. 9

Cameras for Diagaid

Webcam	Kodak / Nikon	digital	360 x 520
3/1 CCD	Hitachi / JVC	analog	630 x 740
Digital	Nikon / Olympus JVC	digital	1600 x 1200

Fig. 10

Comparison of Cameras

Camera	Advantage	Disadvantage
Webcam	Costs Image control	Image quality
CCD	Image control	Special software
Digital Camera	Universal use Image quality	Handling Image control

Fig. 11

macroscopic as well as for microscopy with digital images or digitising analogue images and sending them via internet to any expert in the world (Fig. 9).

We tested 3 kinds of cameras (Fig. 10, 11) : Webcam, 3/1 CCD and digital cameras, generating images of the different size and quality comparing the cameras, we found a general acceptance and a superior function of digital camera : universal use and good image quality (Fig. 11).

An optimal solution is shown here with a Nikon microscope Eclipse mounted by a digital camera Coolpix (Fig. 12).

That means we have a low budget periphery station and may have an expensive central station for storing images a.s.o (Fig. 13).

Optimal solution

Fig. 12

Optimal cost solution for DIAGAID

Fig. 13

Organisation Structure I

Fig. 14

Organisation Structure II

Fig. 15

Looking for an appropriate organization structure, consultation respectively second opinion mode. Periphery user and expert are communicating on the same level and directly. The coordination center has only the task for supervise the exchange of images and information, looking for the managing the exchange the rules collecting all data and evaluating the cost benefit ratio of the system (Fig. 14). The other way means to involve the coordination center in any step, like UICC and AFIP is doing in sampling all question and distributing it to the experts (Fig. 15). This may course some delay in the consultation, if the centre is not working very quickly.

You remember the number of pathologists in developing countries. The number reflects the number of

departments of pathology in the countries so the preparation and use of histological slides is very poor.

Therefore we focused our intention on cytology in this project. This decision is made for following reasons : cytology has the advance of simple and fast preparation, standardisation of staining, a very high slide homogeneity. But only one disadvantage is a low information density (Fig. 16).

We focussed the project to that medical fields cytology is usually covering (Fig. 17).

In the following we have to discuss the limitation of consultation quality we found out in some previous studies. There are three issues we have to deal with : quality of question, information and experience of the expert.

Rationals for Cytology		
Subject	Histology	Cytology
Slidepreparation	-	+
Stainingstandardisation	-	+
Slidehomogeneity	-	+
Informationdensity	+	-

Fig. 16

Cytodiagnostic	
FNA IMPRINT EXFOLIATION PUNCTION	LIVER BREAST THYROID LN SKIN ?
BLOOD LIQUOR URINE GENITAL SMEAR PERITONEAL EFFUSION	

Fig. 17

Fig. 18

Fig. 19

The question quality should be put on a low level and should not exceed simple questions I mentioned.

As we found earlier the probability of a diagnosis is strongly correlating with its quality. It is very certain to diagnose the dignity but the subclassification of tumour is uncertain when making this diagnosis on a video screen. Probably in future it will be better when we are able to use better cameras and video screens with higher resolution (Fig. 18).

At present the technical standard is below the intellectual quality of periphery user and expert's meaning (Fig. 19). That means : listening to a concert by phone you can recognise whether it is music of Mozart or of Beethoven, but you cannot discriminate between Jasha Haifez or Pinkas Zuckerman

playing the violin (Fig. 20).

When the quality of information transferred and electronic information presentation will be increased such questions can be solved very easily (Fig. 21). Despite of all these limitations we have to put some rules to the user. Concerning image quality, quality of clinical data and the above mentioned limitation of Question quality (Fig. 22). As well as some rules to the experts, concerning diagnostic accuracy and diagnostic time (Fig. 23).

These rules will be evaluated in a field test and will be supervised by the coordinator of the project.

Out of previous studies we found 3 important error sources : Information I have to speak about afterwards communication, concerning the overall ac-

Fig. 20

Fig. 21

Demands to user	
Images	Quality number representativity
Clinical Datas	examination results
Clinical Question	diagnosis & differential diagnosis

Fig. 22

Demands to Experts	
Diagnostic accuracy	
Diagnostic time	

Fig. 23

Information Quality (IQ I)
$IQ = f(\text{information density, field quantity})$

Fig. 24

cepted terminology which is an important prerequisite in this project and the technical tool. Information quality can be described as a function of information density and the size of an defined area (Fig. 24). Information density is always a problem in cytology (Fig. 25).

One solution may be a simple gallery technique (Fig. 26) which is available nearly in all graphic programs and can concentrate the information with the disadvantage of the loss of information from the background. Information quality can also be described as a function of information quantity and representativity (Fig. 27). This is one of the major problems in telecytology.

If we cover a whole slide in a $40\times$ magnification

Fig. 25

Fig. 26

Information Quality (IQ II)

$$IQ = f(\text{information quantity, representativity})$$

Fig. 27

Representativity

Number of images for histological and cytological specimens at different magnification

Size mm ²	Magnification		File Size	
	x 4	x40	comp 1:80	uncomp
9	1	100	326 kb	- 32 mb
750 tissue cover slip	82	8334	26.7 mb	- 2.7 gb
1375 cover slip size	150	15278	48.9 mb	- 4.9 gb

C.F.Felten
Human Path. 30 (1999)

Fig. 28

Fig. 29

we need about 15,000 images and will create in uncompressed condition a data volume in about 5 gigabyte, JPEG compressed : 50 megabyte (Fig. 28). These data volumes we cannot transfer on commercial networks, so we have always to select areas.

But what areas do we need? Let me show you an example :

Here you find a detail of a very famous image : Guess the title of the picture (Fig. 29). If you are an great expert you know the name of this image, if you are minor expert, you will put the picture in the time of Italian Renaissance analysing the ground colour, the sky and details of the background.

Even if you are a minor expert, you will recognise the image in the following detail (Fig. 30).

Fig. 30

Fig. 31

Fig. 32

Fig. 33

It is the Mona Lisa from Leonardo da Vinci (Fig. 31). Therefore representativity and personal experience are the key to an optimal telediagnosis.

The time schedule of DIAGAID is divided in 3 phases :

Testing of systems and evaluation of an optimal solution.

Field-test which will begin in some month with feasibility study and the evaluation of the frequency of each user. Permanent establishing of international and national networks.

With the aim of minimising foreign aid and increasing self aid, we calculated a financial request with \$ 7.500 per station and I hope we can reduce the costs with the support of the companies and we calcu-

late the total budget of project at the beginning with about \$ 75.000, 00 which is a very low budget for an international project.

I hope this project will come out as a tool that means the benefit is in adequate relation to the efforts we have to make (Fig. 32). But when the efforts are greater than the benefit this project will be a toy for some people and they would be wasting money, which is needed especially in developing countries.

Let me summarise the aim of the project in the issue. Global economy means global responsibility (Fig. 33). Let me finish my presentation with two pictures : Pieter Breughel the Flemish painter in the 16th century show the worst outcome of the telepa-

Fig. 34

Fig. 35

Fig. 36

thology and telecytology ; a blind beggar is guiding other blind people into a hole - into a catastrophe (Fig. 34). 200 years later a Japanese painter Katsushika Hokusai was painting more optimistic feature, a blind people helping another to cross a river to overwhelm an obstacle (Fig. 35). This should be a symbol for DIAGAID, that means the development medical science is always based on communication (Fig. 36). At last let me thank you for your kind attention and my close co-authors for the help to realise the project ; Dr. Jorg Woziwodzki, Dr. Thiti Kuakpaetoon, Anke Stauch, Sonja Dohn and Hans Diedrichs.

抄 録

われわれは世界各地のラボを結んで、細胞診の向上を目的とし、遠隔医療の手法を用いた国際事業、DIAGAIDを立ち上げる。細胞画像を取り込み、インターネットでエキスパートおよびコーディネータに伝送する。コーディネータは画像から標本の適否を判断、診断所要時間、診断一致状況、コンサルテーションの頻度分析、教育的症例の収集などを行う。このプロジェクトでは、参加全施設の診断精度の向上とともに教育、希少例の収集などが可能となる。

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