Telenuclearmedicine and Cytology - A Collaborative Approach

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Abstract

Applications in telemedicine are technically characterized by connecting remote participants by utilizing communication and information technology. We have established an expert point-to-point network for telenuclearmedicine using TeamViewer® software as a safe internet connection.

By use of this network cytology and nuclear medicine physicians interact in the work-up of thyroid nodules. Basically, ultrasound and cytology images are exchanged between the experts. This low-cost system seems suitable to improve diagnostic accuracy by the rapid interaction of the participating experts.

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Telematics and Related Technologies

The term telematics has been used to describe comprehensive integrated utilizations of telecommunication and information technology (IT) (ill. 1). Within the last 30 years telematics has substantially influenced the development virtually of all areas of economics, science, logistics, medicine and others. Telematics has also brought up new developments in medicine such as telemedicine. However, efficiency and cost-effectiveness of these new technologies must concur with legal and ethical standards especially if medical issues are concerned [1].

Applications in telemedicine are technically characterized by connecting remote participants by utilizing communication and information technology. In this setting patients and physicians may interact in a network for patients’ care. Academic networks represent another type of setting in which medical experts exchange information by the use of IT.

These networks can either be composed as point-to-point or multi-point-connections depending on the number of participants. Recent advances in IT have provided a great variety of technical solutions for establishing networks. Basically, the bandwidth of the routing determines the performance of the network. Simple telemetric applications require lower bandwidth compared with the transmission of high quality still or high-speed video data.

Examples for these different applications are transmissions of simple physiologic parameters (e.g. heart rates, blood pressure etc.), exchange of digital images (e.g. ultrasound, computed tomography images) or video conferences (e.g. live endoscopy).

Networks can be established via commercial internet with the advantage of global accessibility. However, internet based networks are usually characterized by a limited bandwidth and are thus limited in performance. Academic networks offer higher bandwidths and are therefore used in environments where high performance is mandatory.

Teleradiology

Teleradiology has rendered some interesting applications such as outside readings or radiologic consultation over long distances. Recently, it has been stated that outside readings were a common activity among radiology practices in the US [2]. Radiologic consultation can be held as collaborate work with other specialties. In this context the value of secure web-conferencing in the work-up of patients with fibrotic lung disease has been extensively studied by radiologists and pathologists [3].

Essentially, the German Army Medical Corps has gathered sound knowledge in the diagnosis of neurotraumatized patients using conventional x-ray or CT examinations and telemedicine consultation during the last 20 years [4]. Both civil and military patients have been included in this type of consultation for decision making of surgical interventions or conservative treatments.

Custom-build imaging systems with DICOM 3 interfaces are frequently used in teleradiology. Transmission is performed on ISDN or DSL standards with a bandwidth of at least 128 kbps [4]. For video conferencing using H.323 standard a bandwidth of 384 kbps to 8 Mbps depending on standard or high definition protocols is required [5].

Telenuclearmedicine and Cytology

The work-up of thyroid nodules comprises ultrasound and scintigraphy examinations of the thyroid gland [6].
“Cold” nodules should be further examined by fine-needle aspiration biopsy (FNAB). The American Thyroid Association (ATA) Guidelines Taskforce states that FNAB is the most accurate and cost-effective method for evaluating thyroid nodules [7]. We usually perform FNAB of thyroid nodules by ultrasound guidance. Air dried smears of the aspirates are sent to an institute of cytology for staining and microscopic evaluation.

As recommended recently, we have established a regular teleconference via internet between nuclearmedicine and cytology to share clinical, imaging and cytological information [8]. For this purpose individual patients’ data were pseudonymized to match data protection regulations. For the exchange of digitized images the software program “TeamViewerÒ” was used. By the use of this software package a safe point-to-point connection was established. “TeamViewerÒ” is characterized by security features such as random password allocation to allow secure on-time access and 256-bit session encoding. Teleconference partners can either communicate with each other interactively via voice-over-IP (VoIP), telephone conference or chat. A schematic representation of the established network is shown in fig. 2. In our telemedicine setting nuclearmedicine performed as requester and cytology as responder.

For the correct classification of the cytological results the knowledge of clinical, imaging and biochemical parameters is mandatory. The teleconference allows both nuclearmedicine physicians and cytologists to report on characteristics, anomalies or observations that influence diagnostic accuracy (ill. 3).

In contrast to receiving only written reports by cytology, the teleconference offers the advantage of visualization of pathologic cellular changes to the nuclearmedicine physician.

The demonstration of morphologic findings during teleconference by the cytopathologist may improve the acceptance of reports on insufficient aspirates, and therefore the quality of FNAB-technique and preparation of smears by the clinician. In our opinion the teleconference between nuclearmedicine and cytology helps to optimize the patients’ management in complex clinical settings or in case of discrepancies in clinical findings and cytolgical reports, for example by demonstration of unequivocal cytological criteria of malignancy.

In the past we used the described teleconference in those cases in which a complex differential diagnosis impedes therapeutic decisions. To illustrate the benefits of the teleconference two applications are described as follows.

1. Differential Diagnosis of Inflammatory and Neoplastic Disorders of the Thyroid Gland

- Painful chronic autoimmune thyroiditis (Hashimoto’s Thyroiditis (HT)) may be difficult to differentiate clinically from subacute thyroiditis (De Quervain’s Thyroiditis (QT)) [9]. There is some controversy whether this painful HT represents a distinct clinical entity or whether it is a variant of QT. It is of some interest that in some cases who initially present as QT, follow-up examinations reveal a seroconversion with positive anti-TPO antibodies at a later stage (ill. 4, 5).

2. Differential Diagnosis of Neoplastic Lesions of the Thyroid Gland

- According to the ATA management guidelines FNAB is recommended for further work-up of thyroid nodules [7]. Depending on sonographic and clinical features recommendations are made with respect to nodule threshold sizes. In general, nodules larger than 5 to 10 mm should be evaluated by FNAB and cytology.

In our experience teleconferences between nuclearmedicine and cytology may be useful in situations in which direct exchange of information is mandatory for correct interpretation of results. Ill. 6 and 7 show a case with a solitary thyroid nodule and elevated serum calcitonin. The question is whether the nodule represents a c-cell carcinoma or whether the elevated serum calcitonin is due to some extrathyroidal tumor with paraneoplastic calcitonin production. In this case typical morphological findings for c-cell carcinoma could be demonstrated cytopologically.

The incidence of papillary thyroid carcinomas (PTCs) is increasing over the last decades. From epidemiological data there is an incline for PTCs in the United States from 3.6 per 100.000 in 1973 to 8.7 per 100.000 in 2002 [7]. In Germany, PTCs showed an incidence of approx. 4 and 2 in 1980 versus 7.5 and 3.5 per 100.000 in women and men in 2006, resp. [10]. Differentiated thyroid carcinomas are frequently detected by ultrasound examinations. These tumors often show features such as calcifications, hypochoegenicity, irregular and blurred margins or a taller-than-wide sign which are considered as suspicious [11]. However, these ultrasound features are variable, especially in PTCs [12]. For the diagnosis of PTCs distinct cytological criteria have been defined. Therefore, cytology is of high significance in the work-up of thyroid nodules in which PTCs are suspected.
Future Perspectives
Technical Considerations

The network that we have established in our work has some limitations due to a relatively narrow bandwidth of 16 Mbps. Therefore, download and upload times should be improved by higher bandwidths which will be provided in the future.

In our environment network stability was uncritical. However, there might be regions which are susceptible for transmission errors due to electrical instabilities. In those regions, efforts should be made to improve the electrical instabilities.

Commercial internet networks can be regarded as "low cost" systems since transmission fees are reasonable. The PC based TeamViewer® program can be purchased for less than 500 EUR at business rates. Whether these costs will be lowered in the future remains uncertain from our view.

Quality Assurance

After introducing a telemedicine network it is advisable to evaluate its performance characteristics. In a recent work it has been suggested to carry out performance measurements with respect to access quality and usability [13]. Access characteristics measurements should include the speed of response of the network and its availability. Quality characteristics should comprise the quality of the transmitted images as well as the quality of the diagnoses made by support of the telemedicine network. Usability characteristics imply the practical use of the system and associated technical disturbances.

Conclusion

From our experience telenuclearmedicine networks are beneficial in the interdisciplinary work-up of thyroid nodules in which the exchange of expert opinions is indispensable.

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Illustrations

Illustration 1

Overview of the subspecialities of telematics. Previously conferences have been held by radiology and pathology using teleradiology. We have established a collaborative approach between nuclearmedicine and cytology using telnuclearmedicine.

Illustration 2

The point-to-point network between nuclearmedicine and cytology has been realized by a commercial connection using TeamViewer® software.
Illustration 3

Rapid exchange of information concerning technical observations, ultrasound characteristics and cytological findings is considered to improve diagnostic accuracy.

**Nuclear medicine**

- Technique
  - quantity of aspirated material
  - puncture site localized by US
  - macroscopic appearance of aspirated material

- Clinical Information
  - administered medication
  - concomittant malignant diseases
  - previous radiation treatments

**Cytology**

- Technique
  - artifacts
  - quality of smears
  - quantity of cellular elements

- Diagnosis and differential diagnosis
  - reliability of cytologic diagnosis
  - differential diagnostic evaluations

** Improvement Diagnostic Accuracy**
Illustration 4

56-year old female patient who presented with thyroid tenderness. Initially, thyroid antibodies were negative. During follow-up anti-TPO and Antithyroglobulin were elevated. Ultrasound examination demonstrated an ill-defined area with hypoechogenicity in the left lobe of thyroid gland (similar also in the right lobe - not shown).

Illustration 5

FNAB to ill. 4: The smears contained few regular follicle cells in an inflammatory background. In this area some multinucleated giant cells in a granulomateous arrangement favoured the diagnosis of subacute thyroiditis De Quervain.
Illustration 6

68-year old patient who presented with a palpable nodule and elevated serum calcitonin. Ultrasound examination showed a hypoechogenic nodule located in the left thyroid lobe.

Illustration 7

FNAB to ill. 7: At low magnification the highly cellular aspirate showed dissociated uniform cells and some amyloid deposits. At higher magnification some cells demonstrated a triangular configured cytoplasm containing a reddish granulation. The nuclei were elongated and showed intranuclear cytoplasmic inclusion. These findings are consistent with medullary thyroid carcinoma.
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