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A human friendly reporting and database system for brain PET analysis

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We have developed a human friendly reporting and database system for clinical brain PET (Positron Emission Tomography) scans, which enables statistical data analysis on qualitative information obtained from image interpretation. Our system consists of a Brain PET Data (Input) Tool and Report Writing Tool. In the Brain PET Data Tool, findings and interpretations are input by selecting menu icons in a window panel instead of writing a free text. This method of input enables on-line data entry into and update of the database by means of pre-defined consistent words, which facilitates statistical data analysis. The Report Writing Tool generates a one page report of natural English sentences semi-automatically by using the above input information and the patient information obtained from our PET center's main database. It also has a keyword selection function from the report text so that we can save a set of keywords on the database for further analysis. By means of this system, we can store the data related to patient information and visual interpretation of the PET examination while writing clinical reports in daily work. The database files in our system can be accessed by means of commercially available databases. We have used the 4th Dimension database that runs on a Macintosh computer and analyzed 95 cases of ^{18}F-FDG brain PET studies. The results showed high specificity of parietal hypometabolism for Alzheimer's patients.

Key words: database, reporting system, brain PET, statistical analysis, brain PET image visual interpretation

INTRODUCTION

A CLINICAL REPORT on brain PET study is usually written by a clinician and contains data and information about the patient and the PET examination. Since such data consist of patient age and gender, clinical diagnosis, and interpretation of the PET findings together with the level of specific functions in specific brain regions, they can serve as a good source of information for a case study and statistical analysis of PET findings, but these reports are usually written in free style, and the nomenclature is not always consistent. A physician may write "Decreased FDG uptake in parietal cortex and temporal cortex, suggesting Alzheimer's disease," while another may report "Temporoparietal hypometabolism compatible with DAT" to express the same idea. It is therefore not easy to search for specific cases or do statistical analysis on these reports even if the entire text of every patient PET report is stored as a text file.

Several radiological reporting systems are reported,[1-3] some of which use speech recording. In addition a nuclear medicine reporting system with a graphical interface[4] may be useful in generating reports. Most of these systems have computerized reporting as their main goal. Although they provide convenient tools for generating such reports, they do not offer ways of creating a database for data analysis. Clinical reports are to be generated out of every PET scan as routine daily work. It would be quite convenient and efficient for clinicians and researchers if the reports could be stored in a well-structured database for later retrieval analysis without other work in addition to the conventional report writing.

We have developed a brain PET database (BP_Database) and reporting system that enables us to perform qualitative data analysis on the information obtained from the reports of PET examinations. Our system provides a user friendly man-machine interface for on-line data entry and update and retrieval of the brain PET examination data, and can semi-automatically generate a computerized re-

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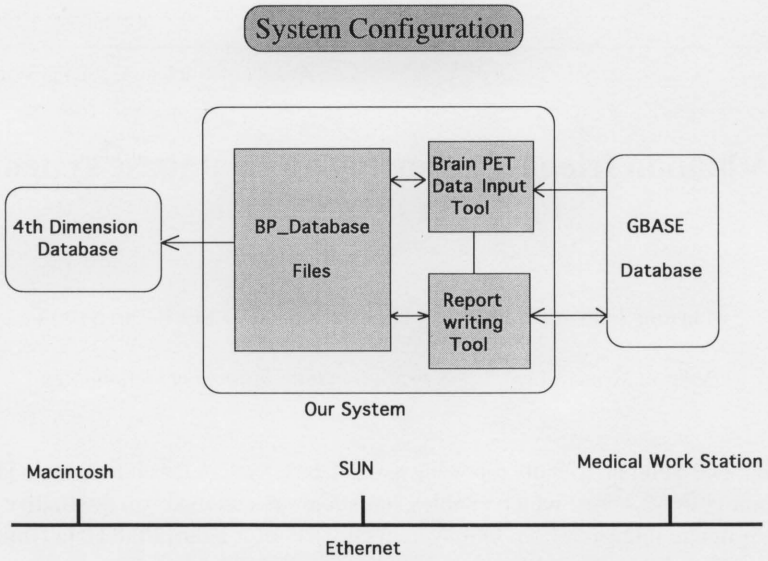

Fig. 1 Block diagram of the system configuration.

port. A physician is prompted to describe the PET findings by combinations of "where" (e.g., bilateral parietal lobe), "what" (e.g., cerebral glucose metabolism), and "how" (e.g., low). We can store these findings in the database with pre-defined terms in a logical architecture and retrieve or analyze them easily. A keyword selection option in the reporting system makes it possible to select a set of keywords from the report and to store them in the database for further analysis. To make our system portable, we have designed our database files in such a way that we can access them by means of commercially available relational databases. For data analysis the user has the option of choosing a database with which he is familiar. As an example of utilizing the database created by our system, we performed an analysis of 95 cases of ^{18}F-FDG brain PET reports by using a "4th Dimension database (ACIUS Inc. & ACI)" which runs on a Macintosh computer.

SYSTEM CONFIGURATION

A block diagram of system configuration is shown in Figure 1. It shows the main parts of our system and the flow of data within our system as well as from some other computers in our PET center. Our system is programmed on a SUN computer in a UNIX environment using C language and the XVIEW window system. It consists of BP_Database files and two main routines named Brain PET Data (Input) Tool and Report Writing Tool. Each tool runs on a separate window. They provide methods for on-line data entry into and update of information in the BP_Database. The BP_Database files contain the data related to patient information, scanning information, PET findings and interpretation and keywords.

The information on the patient and the PET scanning (patient name, age, sex, tracer name, number of PET scans, etc.) is written in the header of the data files at the time of data acquisition and stored in the main database of our PET center (GBASE: Ricoh Co., Ltd., Tokyo). We have programmed a routine in the report writing tool that reads such data from GBASE. This tool is also capable of updating some of the data in GBASE.

1. Brain PET Data Tool

Figure 2 shows the layout of the Brain PET Data Tool. The nuclear physician interprets the PET images by visual inspection by means of X-ray CT and/or MRI for anatomical reference if necessary. He extracts findings such as low cerebral blood flow, high FDG uptake, etc., in specific regions of the brain. To handle these data we set up a large number of menu icons. By clicking these icons, the physician can input, update or retrieve the results of visually inspected data in the BP_Database. We have composed the brain PET findings of six elements: brain location, laterality, measured function, level of the value, interpretation and the diagnosis (disease name) as shown in Figure 2. Menu icons are also displayed as choices for each element. The brain location can be grossly described as frontal lobe, temporal lobe, parietal lobe, occipital lobe, etc., or detailed with sub-region. A total of 72 sub-regions are defined.[5] The measured PET function can be the cerebral metabolic rate of glucose (CMRGlu), FDG uptake, methionine uptake (Met uptake) or cerebral blood flow (CBF), etc. The level of the PET function is classified into low, normal, high or unknown as shown in the VALUE in Figure 2. The interpretation of above findings can be ischemia, degeneration, remote effect, tumor or infarction, etc. The diagnosis can be Alzheimer's disease or Cerebral infarction, etc. We can select a combination of a maximum of 5 locations out of 72, up to five PET functions, one value level and one interpretation. In addi-

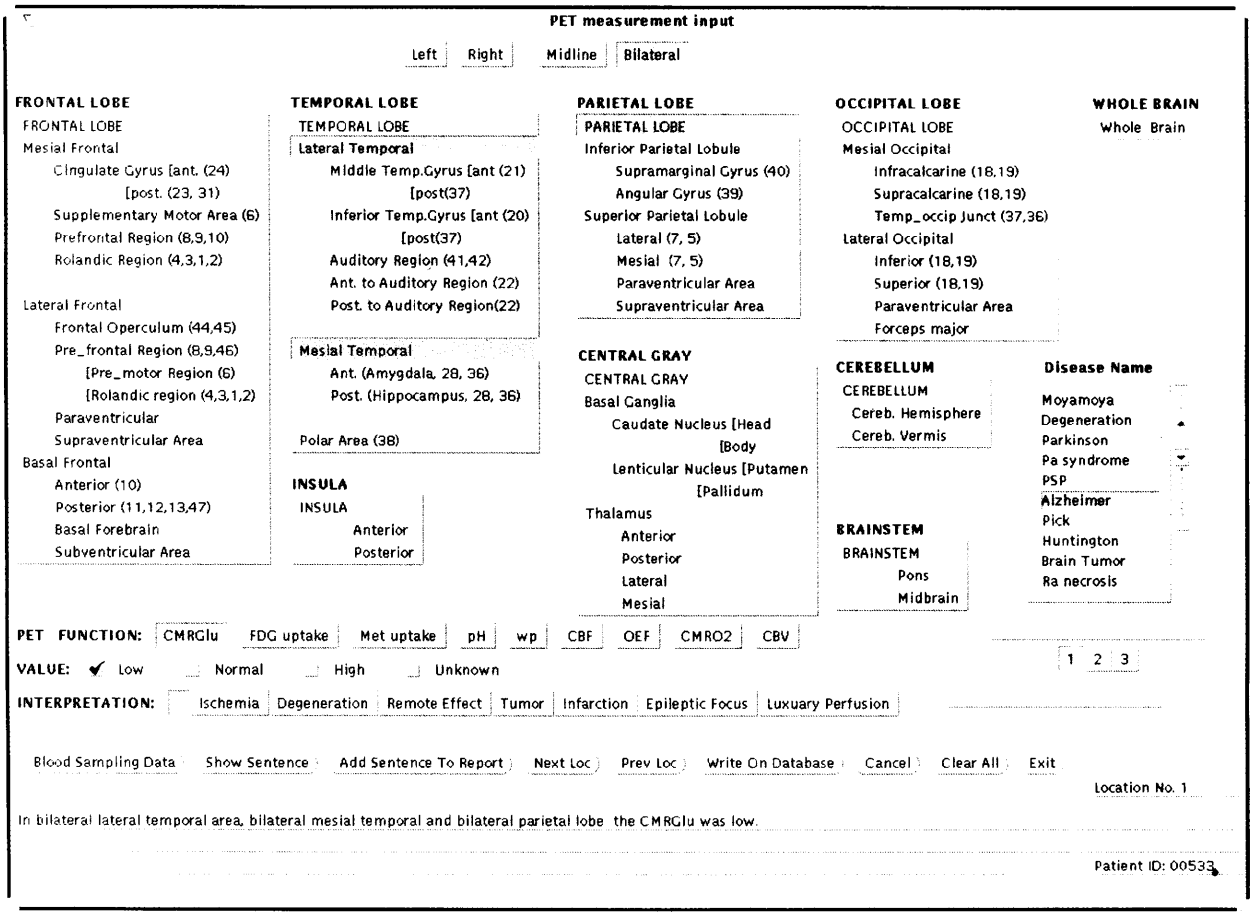

Fig. 2 Layout of the brain PET Data Tool window. The selected icons are seen in gray color.

tion, up to 5 disease names (diagnosis) can be selected for a patient. The physician is strongly encouraged to select his/her choice items from pre-defined icons in order that we can use these items efficiently in a database. As for diagnosis and interpretation, however, he/she can type in words on the keyboard if they are not available in the menu. This system accepts up to 5 sets of such data as described above for each patient.

Retrieval of a patient's data from the BP_Database can be done by entering the patient ID and study number. The retrieved data are displayed in the window with the corresponding menu icons and/or alphanumeric data highlighted. We can update the brain PET data by canceling the highlighted icons (i.e., clicking on an already selected menu icon will dis-highlight or cancel it), and selecting new ones. The "Show Sentence" icon in the bottom part of Figure 2 prompts the computer to build an English phrase out of the words selected above. This phrase is transferred to the Report Writing Tool by the "Add Sentence To Report" icon. The information input or edited in this panel is saved in the BP_Database by the "Write On Database" icon. In addition a control menu is provided to control the overall system.

2. Report Writing Tool

The Report Writing Tool that runs on a separate window can semi-automatically generate a one page report on the results of PET examination. Figure 3 shows the layout of the Report Writing Tool window. The patient's basic data and the data related to the PET study are automatically obtained from the GBASE and shown on the upper part of the window.

To group the data records, we have divided the report screen into 5 sections named clinical diagnosis, complication, other-aspect, PET results and bottom line. The physician inputs a free text in the space designated for each section. Our system, however, fills the PET results section with English phrases and sentences automatically generated from the data available in the BP_Database. The physician is permitted to edit these sections as well.

This tool provides a keyword selection routine. The keywords can be symptoms, clinical parameters or special features in the PET examination. By pressing the up, down, left or right arrow keys on the keyboard, we can select keywords from the words and phrases shown in the above five sections of the report text. The selected keywords are classified into five groups, corresponding to the five sections of the report text. A keyword selected in a

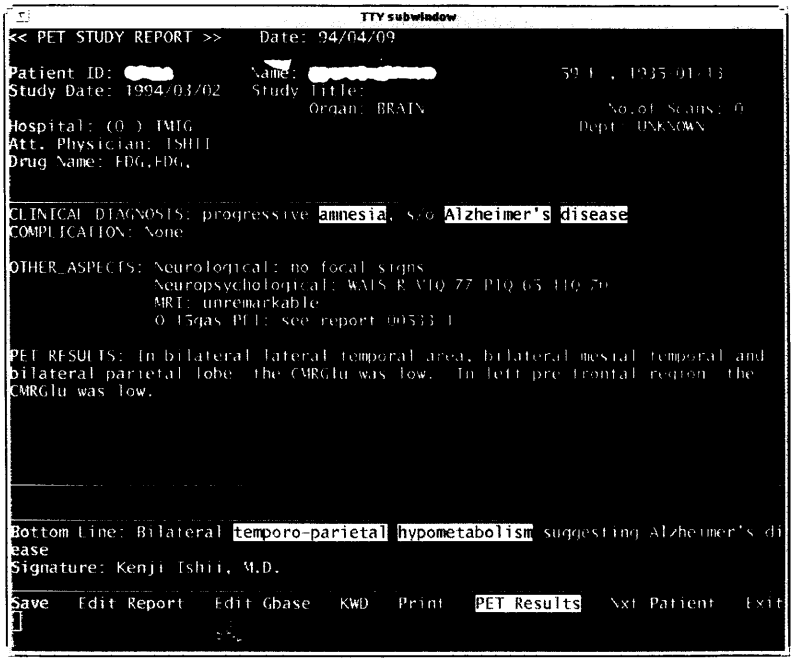

Fig. 3 Layout of Report Writing Tool window. In the upper section, the data obtained from GBASE are displayed (i.e. name, age, sex, tracer name, and so on). The middle part is the report text area and is divided into subareas. In the lower part, the diagnosis made and the physician name are input.

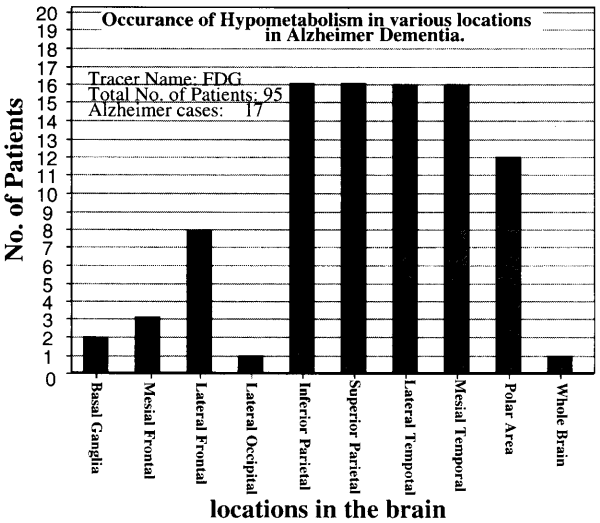

Fig. 4 The occurrence of hypometabolism in various locations in Alzheimer's brain. It shows that parietal and temporal lobes are the most common regions with hypometabolism in patients with Alzheimer.

section defines the relationship between that section name, the keyword itself and the diagnosis. The keywords along with patient ID and the PET examination study number are saved on BP_Database files for further analysis.

Eight control menus are displayed at the bottom part of this window. We can save the report text and edit the report and the data obtained from GBASE and keyword selection by using the control menus. By activating the "PET_RESULT" menu, we can generate the natural language sentences from the words selected by the Brain PET Data Tool. By selecting the "PRINT" menu, we can print the report on a one page A4 size sheet of paper.

APPLICATION AND SYSTEM PERFORMANCE

Method: We have tested the performance of this system in brain PET studies. The subjects were 95 patients with neurological disorders who underwent an ^{18}F-FDG PET study of the brain in our PET center. Among them were 17 cases with dementia of Alzheimer type (DAT), 13 cases with progressive supranuclear palsy (PSP) and 10 cases with temporal lobe epilepsy (TLE). The regional cerebral glucose metabolism was evaluated with an intravenous injection of 100–200 MBq of ^{18}F-FDG followed by a PET scan with HEADTOME IV (Shimadzu Co., Ltd., Kyoto),[6] starting 45 minutes after injection. The regional radioactivity of the brain divided by the administered dose per body weight makes differential uptake ratio (DUR) images that reflect the regional cerebral glucose metabolism. The results of the PET studies were saved in the BP_Database as described in the previous sections. By using the 4th Dimension, the following two types of statistics were calculated: (i) the incidence of hypometabolism in various brain locations in each disease, and (ii) the incidence of various diseases when hypometabolism is observed in certain brain locations.

Results: The time required for data entry was about a few minutes per case. Figure 4 shows the occurrence of hypometabolism in various locations of the brain in the cases with DAT. Temporal and parietal hypometabolism was seen in most DAT cases. In about a half of the cases,

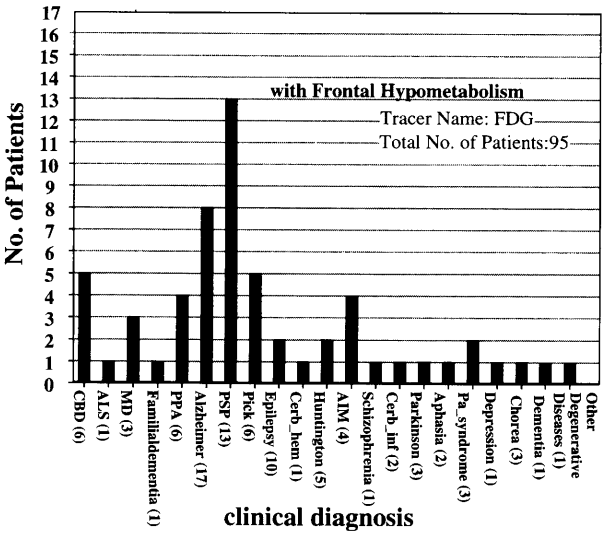

Fig. 5 The frequency of clinical diagnoses in patients presenting frontal hypometabolism. The total number of patients with the disease is shown in parentheses. (CBD: corticobasal degeneration, ALS: amyotrophic lateral sclerosis, MD: myotonic dystrophy, PPA: primary progressive aphasia, PSP: progressive supranuclear palsy, Cereb_hem: cerebral hemorrhage, Cereb_inf: cerebral infarction, AIM: abnormal involuntary movements, Pa_syndrome: Parkinsonian syndrome)

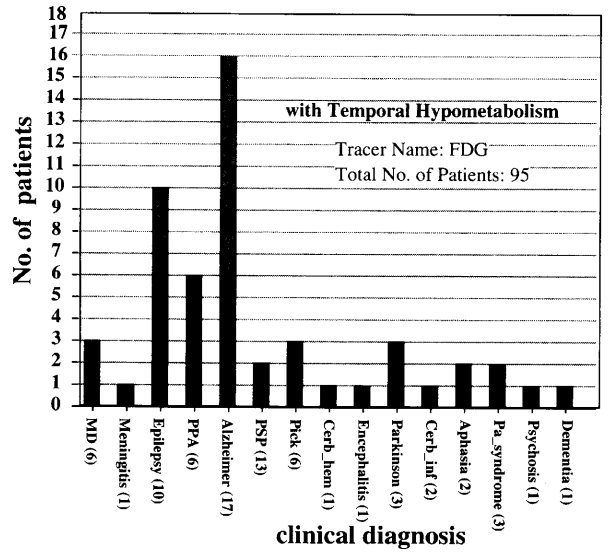

Fig. 6 The frequency of diagnosis of patients presenting temporal hypometabolism. The total number of patients with the disease is shown in parentheses. See Fig. 5 for abbreviations.

frontal hypometabolism was also observed. Figures 5, 6 and 7 show the frequency of clinical diagnosis in the subjects who had frontal hypometabolism, temporal hypometabolism or parietal hypometabolism, respectively. The numbers in parentheses show the total number of patients with each disease, respectively in these figures. Among the subjects with frontal hypometabolism, PSP was the most frequent, followed by DAT, Pick's disease

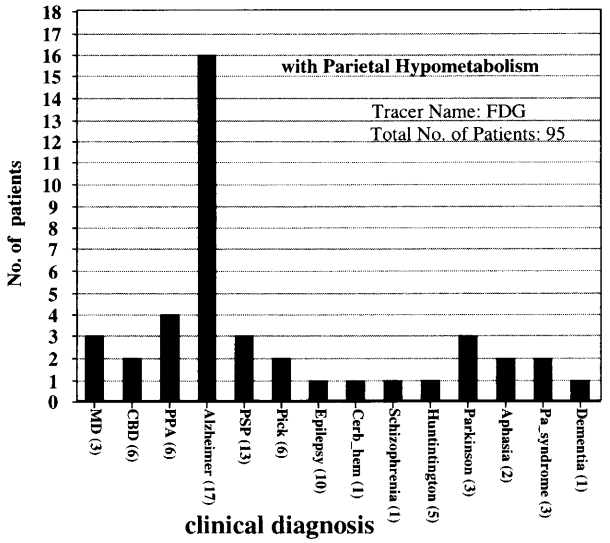

Fig. 7 The frequency of diagnosis of patients presenting parietal hypometabolism. Suggesting parietal hypometabolism is a highly specific finding in patients with Alzheimer. The total number of patients with the disease is shown in parentheses. See Fig. 5 for abbreviations.

and corticobasal degeneration, as shown in Figure 5. Among the subjects with temporal hypometabolism (Fig. 6), DAT was the most frequent. All cases with TLE also had temporal hypometabolism in this study. Figure 7 shows that among the cases with parietal hypometabolism, DAT tops all the other diseases, suggesting that parietal hypometabolism is a highly specific finding of DAT.

DISCUSSION

Unlike other existing reporting systems[1-4] which have as their main goal the generation of a computerized report, we have developed a reporting system that runs in combination with a database for the brain PET studies (BP_Database). Our system provides a convenient man-machine interface for generating and saving the results of brain PET examinations in the BP_Database. By sharing the information available from the BP_Database the reporting system can semi-automatically generate a one page report for the patient. Since our system connects with the main database "GBASE" of our computer system, the PET images are retrieved and displayed when they are to be interpreted.

We input the findings and interpretation with the Brain PET Data Tool, in which the window panel displays almost all essential words as menu icons. These words are used in the visual interpretation of brain PET images. These menu icons are grouped together and positioned on the window panel in such a way that one can easily enter the results of visual interpretation by clicking the corre-

sponding icons. An advantage of data entry by menu icons is that we are able to use consistent words and store them in the database to express similar notions, regardless of the wording preference of the physician. The terms provided by the menu icons may not be sufficient to precisely describe the findings and interpretations or to express suitable ideas. Wording consistency, however, is important when we store the data in the database, because it facilitates retrieval and statistical analysis.

The report is written with the Report Writing Tool, in which a large part of the contents is generated automatically. Patients' basic information including age and sex, as well as scanning information such as study date and tracer name, are obtained from the GBASE database, which is our data management system. When our system is used in other centers or hospitals, they can obtain such data from their HIS (Hospital Information System) if they have one, or from the header of the PET image files, with minor modifications.

The text of the PET results is composed automatically as grammatically correct English sentences from the selected words in the Brain PET Data Tool as sets of words representing the location, measured function, its level and interpretation. This logically structured way of handling patient information and medical data could lead to the development of the "computerized medical record" in the future.

At present our database acquires the data from visual interpretation of brain PET images. As a result we can only perform qualitative analysis with our database. We obtain quantitative data by means of ROIs selected on the PET images as a set of numerical values representing the level of regional cerebral functions. Methods are being developed to determine the ROIs automatically.[7] If such methods become available, they can be combined with our system. The new system will provide a quantitative database on regional cerebral functions, which will allow quantitative analysis of PET data in a shorter time.

Although our system is designed and used for brain PET data, it can be used for brain SPECT images as well. We can also apply it, with some modifications, to PET, SPECT or scintigraphy of other organs.

The BP_Database files are written in ASCII format with a TAB character code between fields. This format matches the file format of most of the commercially available databases. We have performed data analysis with the 4th Dimension database, which allows a variety of data analysis without programming requirements. The data analysis we did here, as well as the graphical figures presented in this paper, did not need any additional programming.

As an example of the application of our database, we have analyzed 95 cases of ^{18}F-FDG brain PET. The results indicated a high incidence of temporal and parietal hypometabolism in Alzheimer patients and a high incidence of Alzheimer's disease in patients with parietal hypometabolism, consistent with previous reports.[8–10]

CONCLUSION

We have developed a human friendly reporting and database system for clinical brain scans, which enables statistical data analysis on qualitative information obtained from image interpretation. Findings are input with predefined consistent words by selecting menu icons instead of writing a free text. This method of input facilitates statistical data analysis. A one page report is generated semi-automatically with natural English sentences from the above input information and the patient information. It also has a keyword selection and saving function from the report text. This system is very useful and efficient because we can store the data concerning patient information and PET interpretation in the database, while writing the clinical report as a daily work. The database files of our system can be accessed by most of the commercially available databases. The analysis of 95 cases of ^{18}F-FDG brain PET studies indicated high specificity of parietal hypometabolism for Alzheimer, which confirmed a well known characteristic of the disease.

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