A MULTIMEDIA DATABASE FOR MUSCULOSKELETAL TUMOUR SURGERY

BY

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List of abbreviations

AMA	American Medical Association
COSTAR	The Computer Base Ambulatory Record System
COTDS	Computerized Operation Theatre Documentation System
CT	Computer tomography
DICOM	Digital Image Communication for Medicine
DV	Digital Video
DVD-R	Digital Video Disc Recordable
EMR	Electronic Medical Record
HIS	Hospital Information System
ICD	International Classification of Disease
IOM	Institute Of Medicine
JPEG	Joint Photographic Expert Group
MRI	Magnetic resonance imaging
MPEG	Motion Picture Expert Group
ORCA	Open Record For Care
PACS	Picture Archiving And Communication System
PDA	Personal Digital Assitant
SHREWD	Stanford Hospital Record Electronic Web Documents
TMR	The Medical Record
WWW	World Wide Web

Abstrak

Pengurusan pesakit kanser otorangka menghasilkan begitu banyak data. Disamping data asas pesakit yang boleh disimpan dalam bentuk teks dan nombor, terdapat juga data multimedia yang terdiri dari gambar-gambar, imej-imej radiologi dan juga klip video. Ianya perlu disimpan dalam rekod pesakit bagi memperbaiki pengurusan pesakit. Satu cara yang berkesan untuk menyimpan data yang begitu banyak sangat diperlukan. Pangkalan data multimedia boleh digunakan untuk tujuan tersebut. Ianya akan memudahkan tugas-tugas odit klinikal, penyelidikan dan juga pembelajaran.

Satu pangkalan data multimedia untuk pembedahan kanser ototrangka telah dibangunkan dengan menggunakan perisian Microsoft Access™ 2000 yang boleh digunakan di atas kebanyakan komputer yang ada pada hari ini. Pangkalan data itu kini menyimpan rekod 170 orang pesakit. Saiz pangkalan data utama ialah 4 megabait dan data multimedia ialah sebanyak 5 gigabait.

Pangkalan data sedia ada iaitu Lifeline® cuma menyimpan data asas pesakit, sementara pangkalan data Pathspeed PACS hanya meyimpan imej-imej radiologi sahaja. Pangkalan data

ini boleh menyimpan semua data tersebut dan juga data multimedia pada satu tempat.

Jika dibandingkan dengan system rekod perubatan tradisional berasaskan kertas, pangkalan data ini lebih mudah untuk dibaca. Ianya mempunyai data yang berstruktur dan berpusat di satu tempat. Pangkalan data multimedia tersebut boleh memudahkan kemasukan dan pengkodan data, selain daripada memudahkan capaian kepada data multimedia pesakit. Ianya boleh menjana statistik asas secara otomatik dan spontan yang membantu tugas odit dan penyelidikan. Data multimedia yang diperolehi boleh digunakan untuk tujuan pembelajaran dan penyediaan persembahan saintifik.

Abstract

Management of patients with musculoskeletal tumour produced a lot of data. Besides the basic patients' data that can be stored as texts and numbers, there are also multimedia data which consists of photographic images, radiological images as well as video clips that need to be stored to improve patient care. An efficient method to manage the large amount of data is needed. A multimedia database system can be used to achieve this goal. It will facilitate clinical audit reporting, research and education.

A multimedia database for musculoskeletal tumour surgery was developed using Microsoft Access™ 2000 that runs on the majority of windows-based personal computers. The database currently has records of 170 patients. The main database is 4 megabytes in size and the multimedia data occupied 5 gigabytes of storage.

The present hospital database Lifeline® only stores the basic patients' demographic data and the Pathspeed® PACS only stores the radiological image data whereas this database can store all the above data which include the multimedia data.

Compared to the traditional paper-based record system, the database offered improved legibility and centralized and structured data. It has eased the entry and coding of data, searching as well as providing easy access to the patients' multimedia data. It can automatically output basic descriptive statistics in a real-time manner that helps in clinical audit and research. The multimedia database is also useful for education and preparation of scientific presentations.

1.0 Introduction

The management of patients with musculoskeletal tumour is one of the most challenging fields in orthopaedic surgery. A multidisciplinary team which includes oncology surgeons, plastic reconstructive surgeons, anaesthetists, musculoskeletal radiologists, medical and radiation oncologists, pathologists, psychiatrists and physiotherapist is involved in their treatment. All the team members from different departments produced lots of data for each patient.

In order to provide optimum care for the patients, good coordination and teamwork between members have to be established. One the first steps toward achieving this goal is to have proper documentation of patients' data. Traditionally, the documentation is provided in the patients' medical records. With so many care providers giving care to the patient and different types of data being generated, the traditional paper-based medical record keeping can no longer provide an effective means of documentation. It lacks structure, legibility and is not easily accessible to the different care providers. Furthermore, there is no effective way to store and retrieve the vast amount of multimedia data being generated for the patient. There is a real and urgent need to find a new way to integrate all this data.

The Institute of Medicine (IOM) of the United States National Academy of Sciences has come up in 1991 with a proposal for an electronic medical record keeping to overcome the problems associated with traditional paper-based medical record (Detmer *et al*, 1991). In its vision, the IOM stated that "the future medical record will be a computer-based multimedia system capable of including free text, high resolution images, sound, full-motion video and an elaborate coding scheme". A decade after this prediction, the ideal medical record has not yet been realized (Stoodley *et al* 2001).

Globally, more and more hospitals are implementing electronic medical record systems. Most hospitals in the United States now have some type of Hospital Information System (HIS) in place (Tang C.P, Hammond E.W 1997). In Europe a large number of hospitals now use computerized information systems but they are mainly for administrative purposes and not for patient data, except for laboratory information, prescriptions and diagnostic codes. In out-patient settings, by early 1996 electronic medical records is used by more than 90% of general practitioners in the Netherlands and the United Kingdom. (Bemmel J.H, 1999).

Among Dutch general practitioners, more than 50% have an electronic medical record and 25% have a paperless office, with similar figures for the United Kingdom. In Japan, more than half (54.1%) of hospitals have a hospital information system (Latimer E.W, 1999). The same systems are use for inpatients and outpatients settings.

In Malaysia almost all big government hospitals have hospital information system. But these systems only support administrative and financial data. The migration towards a complete electronic medical record system was pioneered by Selayang Hospital. In what is called Total Hospital Information System or THIS, the hospital information system is expanded to include the patient data (Versweyveld L, 2001). Basic patients' data as well as radiological images, laboratory and vital signs monitoring data are easily accessible by the bedsides and remotely using a sytem called Ultraview Care Network® from Spacelabs Inc, United States of America. Putrajaya Hospital also has implemented THIS and the outpatient module is implemented in Klinik Putrajaya. USM hospital has not yet implemented an electronic medical record system. What we have in place now is a Hospital Information System (Lifeline®) and a few isolated databases. A Picture Archiving and Communication System (PACS), PathSpeed® PACS and a radiology information system (RIS), PARIS® is already implemented in the radiology department. The pathology department has a database for histopathology case reporting. The Operation Theatre has Computerized Operation Theatre documentation system (COTDS) from the Malaysian Ministry of Health. All these databases are standalone systems and not accessible by other departments except for PathSpeed® PACS.

What is common in the implementation of electronic medical record so far is a conversion of textual data into an electronic form with some form of picture archiving and communication systems. Up to now there is no established system that integrates the text, images, video and sound in an electronic medical record system.

The main purpose of an electronic medical record system is for improvement of patient care. It will also be a repository of data for clinical audit, research and education. As the ideal electronic medical record is yet to be realized, a multimedia database will greatly help in achieving the above-mentioned goals. A multimedia database for musculoskeletal tumour surgery will form a foundation for the future multimedia electronic medical record system that can be further adapted to all the different medical disciplines. A complete electronic multimedia medical record system is beyond the scope of this study since it will necessitate enterprise level commitment. What we want to achieve is a simple multimedia database for musculoskeletal tumour surgery that can be easily used and adapted for our purpose of searching basic patient and multimedia data for clinical audit, research and education.

2.0 Literature Review

Definition

A database is a repository of data that traditionally contains text, numeric values, Boolean values and dates related to a particular subject or purpose (Golshani & Dimitrova, 1998). A multimedia database additionally contains images, video clips, sound and graphical animation. A multimedia database for musculoskeletal tumour surgery is thus a collection of information for a patient with musculoskeletal tumour that has all types of data mentioned above. It can contain the clinical data of the patient, radiological images, clinical photographs, operative photographs as well as video clips and sound and other forms of biological recordings.

2.1 The Medical Record

The earliest written description of a medical record was described 2600 years ago by Hippocrates (Bemmel J.V, Mussen, M.A. 1999). In this record Hippocrates described in a step-by-step fashion the disease process that afflicted Appolinius. He began with the history, followed by his description of the disease process and later the progress of the patient until the time of death. This description of disease by Hippocrates is termed as a time-oriented medical record.

'Απολλώνιος ὀρθοστάδην ὑπεφέρετο χρόνον πολὺν. ἦν δὲ μεγαλό–σπλαγχνος, καὶ περὶ ἧπαρ συνήθης ὀδύνη χρόνον πολὺν παρείπετο, καὶ δὴ τότε καὶ ἰκτερώδης ἐγένετο, φυσώδης, χροιῆς της ὑπολεύκου. φαγὼν δὲ καὶ πιὼν ἀκαιρότερον βόειον ἐθερμάνθη σμικρὰ τὸ πρῶτον, κατεκλίθη. γάλαξι δὲ χρησάμενος ἑφθοῖσι καὶ ὠμοῖσι πολλοῖσιν, αἰγείοισι καὶ μηλείοισι, καὶ διαίτῃ κακῇ πάντων, βλάβαι μεγάλαι. οἵ τε γὰρ πυρετοὶ παρωξύνθησαν, κοιλίη τε τῶν προσενεχθέντων οὐδὲν διέδωκεν ἄξιον λόγου, οὖρά τε λεπτὰ καὶ ὀλίγα διῄει. ὕπνοι οὐκ ἐνῆσαν. ἐμφύσημα κακόν, πολὺ δίψος, κωμα–τώδησ, ὑποχονδρίου δεξιοῦ ἔπαρμα σὺν ὀδύνῃ, ἄκρεα πάντοθεν ὑπό–ψυχρα, σμικρὰ παρέλεγε, λήθη πάντων ὅ τι λέγοι, παρεφέρετο. περὶ δὲ τεσσαρεσκαιδεκάτην, ἀφ' ἧς κατεκλίθη, ῥιγώσας ἐπεθερμάνθη. ἐξεμάνη. βοή, ταραχή, λόγοι πολλοί, καί πάλιν ἵδρυσις, καὶ τὸ κῶμα τηνικαῦτα προσῆλθε. μετὰ δὲ ταῦτα κοιλίη ταραχώδης πολλοῖσι χολώδεσιν, ἀκρή–τοισιν, ὠμοῖσιν. οὖρα μέλανα, σμικρά, λεπτά. πολλὴ δυσφορίη. τά τῶν διαχωρημάτων ποικίλως. ἢ γὰρ μέλανα καὶ σμικρὰ καὶ ἰώδεα ἢ λιπαρὰ καὶ ὠμὰ καὶ δακνώδεα. κατὰ δὲ χρόνουσ ἐδόκει καί γαλακτώδεα διδόναι. περὶ δὲ εἰκοστὴν τετάρτην διὰ παρηγορίης. τὰ μὲν ἄλλα ἐπὶ τῶν αὐτῶν, σμικρὰ δὲ κατενόησεν. ἐξ οὗ δὲ κατεκλίθη, οὐδενὸς ἐμνήσθη. πάλιν δὲ ταχὺ παρ–ενόει, ὥρμητο πάντα ἐπὶ τὸ χεῖρον. περὶ δὲ τριηκοστὴν πυρετὸς ὀξύς, διαχωρήματα πολλὰ λεπτά, παράληρος, ἄκρεα ψυχρά, ἄφωνος. τριηκοστῇ τετάρτῃ ἔθανε.

Apollonius was ailing for a long time without being confined to bed. He had a swollen abdomen, and a continual pain in the region of the liver had been present for a long time; moreover, he became during this period jaundiced and flatulent: his complexion was whitish."

After dining one day and drinking to excess, Apollonius "at first grew rather hot and took to his bed. Having drunk copiously of milk, boiled and raw, both goat's and sheep's, and adopting a thoroughly bad regimen, he suffered much there from."

There were exacerbations of the fever; the bowels passed practically nothing of the food taken, the urine was thin and scanty. No sleep. Grievous distention, much thirst, delirious mutterings. ..... About the fourteenth day from his taking to bed, after a rigor, he grew hot; wildly delirious, shouting, distress, much rambling, followed by calm; the coma came on at this time . . . . About the twenty-fourth day comfortable; in other respects the same, but he had lucid intervals. ..... About the thirtieth day acute fever; copious thin stools; wandering, cold extremities, speechlessness. Thirty-fourth day: Death.

Fig. 2.1 Description of disease by Hippocrates in 6th Century B.C; Greek text with translation. (Handbook Of Medical Informatics, 1999)

William Mayo started a first group practice shortly after 1880 in Rochester, Minnesota, USA. In Mayo clinic, every physician kept medical notes in a personal leather-bound ledger. It contained a chronological account of all patients' encounters. As a result, the notes pertaining to a single patient could be pages apart, depending on the time intervals between visits. The scattered notes made it complicated to obtain a good overview of the complete disease history of a patient. In addition, part of the patient information could be present in the ledgers of other physicians. In 1907, the Mayo Clinic adopted a one separate file system for each patient.

This innovation was the origin of the patient-centered medical record keeping. The fact that all notes were kept in a single file, however, did not mean that there was a set criterion of contents for record keeping. In 1920, the Mayo Clinic management agreed upon a minimal set of data that all physicians were compelled to record. This set of data became more or less the framework for the present-day medical record keeping system.

Despite this initiative toward standardization of patient records, their written contents were often a mixture of complaints, test results, considerations, therapy plans, and findings. Such unordered notes did not provide clear insight, especially in the case of patients who were treated for more than one complaint or disease.

Weed tackled the challenge to improve the organization of the patient record, and in the 1960s he introduced the problem-oriented medical record system. (Weed L, 1969). In this problem-oriented medical record, each patient was assigned one or more problems. Notes were recorded per problem according to the SOAP structure, which stands for subjective (S; the complaints as phrased by the patient), objective (O; the findings of physicians and nurses), assessment (A; the test results and conclusions, such as a diagnosis), and plan (P; the medical plan, e.g., treatment or policy).

Besides further improvement in the standardization and ordering of the patient record, the main purpose of the problem-oriented SOAP structure is to give a better reflection of the care provider's line of reasoning. It is immediately clear to which problem the findings and the treatment plan pertain. Although Weed's problem-oriented record was readily accepted on a rational basis, it proved to require much discipline to adhere to the method in practice. Data associated with more than one problem need to be recorded several times. Figures 2.2, 2.3, and 2.4 provide three versions of the same notes in time-oriented, source-oriented, and problem-oriented formats, respectively.

Feb 21, 1996	Shortness of breath, cough, and fever. Very dark feces. Exam: RR 150/90, pulse 95/min, Temp: 39.3 °C. Rhonchi, abdomen not tender. possibly complicated with cardiac decompensation. Bleeding possibly due to Aspirin. Present medication 64 mg Aspirin per day. Probably acute bronchitis, ESR 25 mm, Hb 7.8, occult blood feces +. Chest X-ray: no atelectasis, slight sign of cardiac decompensation Medication: Amoxicillin caps 500 mg twice daily, Aspirin reduce to 32 mg per day
Mar 4, 1996:	No more cough, slight shortness of breath, normal feces. Exam: slight rhonchi, RR 160/95, pulse 82/min. Keep Aspirin at 32 mg per day Hb 8.2, occult blood feces.

Fig. 2.2 Time-oriented medical record (Handbook Of medical Informatics 1999)

Visits

Feb 21, 1996: Shortness of breath, cough, and fever. Very dark feces.
Exam: RR 150/90, pulse 95/min, Temp: 39.3 °C.
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Mar 4, 1996: No more cough, slight shortness of breath, normal feces.
Exam: slight rhonchi, RR 160/95, pulse 82/min.
Medication: keep Aspirin at 32 mg per day.

Laboratory tests

Feb 21, 1996: ESR 25 mm, Hb 7.8, occult blood feces +.

Mar 4, 1996: Hb 8.2, occult blood feces.

X-rays

Feb 21, 1996: Chest X-ray: no atelectasis, slight sign of cardiac decompensation

Fig. 2.3 Source oriented medical record (Handbook Of medical Informatics 1999)

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Abstract

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1.0 Introduction

The management of patients with musculoskeletal tumour is one of the most challenging fields in orthopaedic surgery. A multidisciplinary team which includes oncology surgeons, plastic reconstructive surgeons, anaesthetists, musculoskeletal radiologists, medical and radiation oncologists, pathologists, psychiatrists and physiotherapist is involved in their treatment. All the team members from different departments produced lots of data for each patient.

In order to provide optimum care for the patients, good coordination and teamwork between members have to be established. One the first steps toward achieving this goal is to have proper documentation of patients' data. Traditionally, the documentation is provided in the patients' medical records. With so many care providers giving care to the patient and different types of data being generated, the traditional paper-based medical record keeping can no longer provide an effective means of documentation. It lacks structure, legibility and is not easily accessible to the different care providers. Furthermore, there is no effective way to store and retrieve the vast amount of multimedia data being generated for the patient. There is a real and urgent need to find a new way to integrate all this data.

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2.0 Literature Review

Definition

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2.1 The Medical Record

The earliest written description of a medical record was described 2600 years ago by Hippocrates (Bemmel J.V, Mussen, M.A. 1999). In this record Hippocrates described in a step-by-step fashion the disease process that afflicted Appolinius. He began with the history, followed by his description of the disease process and later the progress of the patient until the time of death. This description of disease by Hippocrates is termed as a time-oriented medical record.

'Απολλώνιος ὀρθοστάδην ὑπεφέρετο χρόνον πολὺν. ἦν δέ μεγαλό–σπλαγχνος, καὶ περὶ ἧπαρ συνήθης ὀδύνη χρόνον πολὺν παρείπετο, καὶ δὴ τότε καὶ ἰκτερώδης ἐγένετο, φυσώδης, χροιῆς της ὑπολεύκου. φαγὼν δὲ καὶ πιὼν ἀκαιρότερον βόειον ἐθερμάνθη σμικρὰ τὸ πρῶτον, κατεκλίθη. γάλαξι δὲ χρησάμενος ἑφθοῖσι καὶ ὠμοῖσι πολλοῖσιν, αἰγείοισι καὶ μηλείοισι, καὶ διαίτῃ κακῇ πάντων, βλάβαι μεγάλαι. οἵ τε γὰρ πυρετοὶ παρωξύνθησαν, κοιλίη τε τῶν προσενεχθέντων οὐδὲν διέδωκεν ἄξιον λόγου, οὖρά τε λεπτὰ καὶ ὀλίγα διῄει. ὕπνοι οὐκ ἐνῆσαν. ἐμφύσημα κακόν, πολὺ δίψος, κωμα–τώδησ, ὑποχονδρίου δεξιοῦ ἔπαρμα σὺν ὀδύνῃ, ἄκρεα πάντοθεν ὑπό–ψυχρα, σμικρὰ παρέλεγε, λήθη πάντων ὅ τι λέγοι, παρεφέρετο. περὶ δὲ τεσσαρεσκαιδεκάτην, ἀφ' ἧς κατεκλίθη, ῥιγώσας ἐπεθερμάνθη. ἐξεμάνη. βοή, ταραχή, λόγοι πολλοί, καί πάλιν ἵδρυσις, καὶ τὸ κῶμα τηνικαῦτα προσῆλθε. μετὰ δὲ ταῦτα κοιλίη ταραχώδης πολλοῖσι χολώδεσιν, ἀκρή–τοισιν, ὠμοῖσιν. οὖρα μέλανα, σμικρά, λεπτά. πολλὴ δυσφορίη. τά τῶν διαχωρημάτων ποικίλως. ἢ γὰρ μέλανα καὶ σμικρὰ καὶ ἰώδεα ἢ λιπαρὰ καὶ ὠμὰ καὶ δακνώδεα. κατὰ δὲ χρόνουσ ἐδόκει καί γαλακτώδεα διδόναι. περὶ δὲ εἰκοστὴν τετάρτην διὰ παρηγορίης. τὰ μὲν ἄλλα ἐπὶ τῶν αὐτῶν, σμικρὰ δὲ κατενόησεν. ἐξ οὗ δὲ κατεκλίθη, οὐδενὸς ἐμνήσθη. πάλιν δὲ ταχὺ παρ–ενόει, ὥρμητο πάντα ἐπὶ τὸ χεῖρον. περὶ δὲ τριηκοστὴν πυρετὸς ὀξύς, διαχωρήματα πολλὰ λεπτά, παράληρος, ἄκρεα ψυχρά, ἄφωνος. τριηκοστῇ τετάρτῃ ἔθανε.

Apollonius was ailing for a long time without being confined to bed. He had a swollen abdomen, and a continual pain in the region of the liver had been present for a long time; moreover, he became during this period jaundiced and flatulent: his complexion was whitish."

After dining one day and drinking to excess, Apollonius "at first grew rather hot and took to his bed. Having drunk copiously of milk, boiled and raw, both goat's and sheep's, and adopting a thoroughly bad regimen, he suffered much there from."

There were exacerbations of the fever; the bowels passed practically nothing of the food taken, the urine was thin and scanty. No sleep. Grievous distention, much thirst, delirious mutterings. ..... About the fourteenth day from his taking to bed, after a rigor, he grew hot; wildly delirious, shouting, distress, much rambling, followed by calm; the coma came on at this time . . . . About the twenty-fourth day comfortable; in other respects the same, but he had lucid intervals. ..... About the thirtieth day acute fever; copious thin stools; wandering, cold extremities, speechlessness. Thirty-fourth day: Death.

Fig. 2.1 Description of disease by Hippocrates in 6th Century B.C; Greek text with translation. (Handbook Of Medical Informatics, 1999)

William Mayo started a first group practice shortly after 1880 in Rochester, Minnesota, USA. In Mayo clinic, every physician kept medical notes in a personal leather-bound ledger. It contained a chronological account of all patients' encounters. As a result, the notes pertaining to a single patient could be pages apart, depending on the time intervals between visits. The scattered notes made it complicated to obtain a good overview of the complete disease history of a patient. In addition, part of the patient information could be present in the ledgers of other physicians. In 1907, the Mayo Clinic adopted a one separate file system for each patient.

This innovation was the origin of the patient-centered medical record keeping. The fact that all notes were kept in a single file, however, did not mean that there was a set criterion of contents for record keeping. In 1920, the Mayo Clinic management agreed upon a minimal set of data that all physicians were compelled to record. This set of data became more or less the framework for the present-day medical record keeping system.

Despite this initiative toward standardization of patient records, their written contents were often a mixture of complaints, test results, considerations, therapy plans, and findings. Such unordered notes did not provide clear insight, especially in the case of patients who were treated for more than one complaint or disease.

Weed tackled the challenge to improve the organization of the patient record, and in the 1960s he introduced the problem-oriented medical record system. (Weed L, 1969). In this problem-oriented medical record, each patient was assigned one or more problems. Notes were recorded per problem according to the SOAP structure, which stands for subjective (S; the complaints as phrased by the patient), objective (O; the findings of physicians and nurses), assessment (A; the test results and conclusions, such as a diagnosis), and plan (P; the medical plan, e.g., treatment or policy).

Besides further improvement in the standardization and ordering of the patient record, the main purpose of the problem-oriented SOAP structure is to give a better reflection of the care provider's line of reasoning. It is immediately clear to which problem the findings and the treatment plan pertain. Although Weed's problem-oriented record was readily accepted on a rational basis, it proved to require much discipline to adhere to the method in practice. Data associated with more than one problem need to be recorded several times. Figures 2.2, 2.3, and 2.4 provide three versions of the same notes in time-oriented, source-oriented, and problem-oriented formats, respectively.

Feb 21, 1996	Shortness of breath, cough, and fever. Very dark feces. Exam: RR 150/90, pulse 95/min, Temp: 39.3 °C. Rhonchi, abdomen not tender. possibly complicated with cardiac decompensation. Bleeding possibly due to Aspirin. Present medication 64 mg Aspirin per day. Probably acute bronchitis, ESR 25 mm, Hb 7.8, occult blood feces +. Chest X-ray: no atelectasis, slight sign of cardiac decompensation Medication: Amoxicillin caps 500 mg twice daily, Aspirin reduce to 32 mg per day
Mar 4, 1996:	No more cough, slight shortness of breath, normal feces. Exam: slight rhonchi, RR 160/95, pulse 82/min. Keep Aspirin at 32 mg per day Hb 8.2, occult blood feces.

Fig. 2.2 Time-oriented medical record (Handbook Of medical Informatics 1999)

Visits

Feb 21, 1996:	Shortness of breath, cough, and fever. Very dark feces. Exam: RR 150/90, pulse 95/min, Temp: 39.3 °C. Rhonchi, abdomen not tender. Present medication 64 mg Aspirin per day. Probably acute bronchitis, possibly complicated with cardiac decompensation. Bleeding possibly due to Aspirin. Medication: Amoxicillin caps. 500 mg twice daily, Aspirin reduce to 32 mg per day.
Mar 4, 1996:	No more cough, slight shortness of breath, normal feces. Exam: slight rhonchi, RR 160/95, pulse 82/min. Medication: keep Aspirin at 32 mg per day.

Laboratory tests

Feb 21, 1996:	ESR 25 mm, Hb 7.8, occult blood feces +.
Mar 4, 1996:	Hb 8.2, occult blood feces.

X-rays

Feb 21, 1996:	Chest X-ray: no atelectasis, slight sign of cardiac decompensation

Fig. 2.3 Source oriented medical record (Handbook Of medical Informatics 1999)

Problem 1: Acute bronchitis

Feb 21, 1996	S:	Shortness of breath, cough, and fever.
	O:	Pulse 95/min, Temp: 39.3 °C.
		Rhonchi. ESR 25 mm.
		Chest X-ray: no atelectasis, slight sign of cardiac decompensatio
	A:	Acute bronchitis.
	P:	Amoxicillin caps. 500 mg twice daily.
Mar 4, 1996	S:	No more cough, slight shortness of breath.
	O:	Pulse 82/min. Slight rhonchi.
	A:	Sign of bronchitis minimal.

Problem 2: Shortness of breath

Feb 21, 1996	S:	Shortness of breath.
	O:	Rhonchi, RR 150/90.
		Chest X-ray: no atelectasis, slight sign of cardiac decompensation.
	A:	Minor sign of decompensation.
Mar 4, 1996	S:	Slight shortness of breath.
	O:	RR: 160/95, pulse 82/min.
	A:	No decompensation.

Problem 3: Dark feces

Feb 21, 1996	S:	Dark feces.
		Present medication Aspirin 64 mg per day.
	O:	Abdomen not tender, no blood on the glove at rectal examination Hb 7.8.
	A:	Intestinal bleeding possibly due to Aspirin.
	P:	Reduce Aspirin to 32 mg per day.
Mar 4, 1996	S:	Normal feces.
	O:	Occult blood feces.
	A:	No more sign of intestinal bleeding.
	P:	Keep Aspirin at 32 mg per day.

Fig. 2.4 Problem oriented medical record (Handbook Of medical Informatics 1999)

With the rapid progress in medical field, can the present paper-based medical record serve its purposes? To answer this question we need to have a look at what is the purpose of a medical record. The most important use for medical record remains the support for patient care. It is a source for evaluation and decision-making, as well as a source of information that is shared among care providers. It is also a legal document that record medical actions taken. As there is a need for continuous improvement of care, data from medical records are also important for research purposes. It is also important for the education of clinicians. In terms of administrative and financial management, medical records provide data for billing and reimbursement, support for organizational issues and cost management.

Although medical notes are usually recorded on paper, paper-based notes have disadvantages that mainly stem from medical progress. The enormous growth of medical knowledge has led to an increasing number of clinical specialties. Specialization leads to multidisciplinary care, so that more than one care provider is involved in a patient's treatment. In such a setting, one physical record per patient causes too many logistical problems. Therefore, there are often as many records for a patient as there are specialties involved in his or her treatment. Patient data then become scattered among a variety of sources. When clinicians want to form a complete picture about a patient's health, they may need to consult records that are kept by their colleagues. Paper files can only be in one location at a time, and sometimes they cannot be found at all. Handwriting may be poor and illegible, data may be missing, or notes may be too ambiguous to allow proper interpretation.

The rapid advances in medical information and technology now made it possible for specialists to have state-of-the-art knowledge at their fingertips. Yet, patients are treated according to the best insight of the physician. A fundamental limitation of paper-based records is that they can only contribute passively to the decision making of the clinician. The record cannot actively draw the care provider's attention to abnormal laboratory values, contraindications for drugs, or allergies of the patient, for example, to iodine and penicillin.

Beside limitations that directly involve patient care, the paper-based records also have disadvantages that are related to research purposes and healthcare planning. To support these goals, patient data need to be unambiguous, well structured, and easily, but not unlawfully, accessible. Respecting the privacy of the patient is a topic of continuous concern.

It is obvious that retrospective research on the basis of large numbers of paper-based records is extremely laborious and that many data would prove to be missing or useless. This is one important reason why most studies are conducted prospectively. (Bemmel J.V, 1999).

2.2 The Electronic Medical Record

Development of electronic medical record was brought about by the ever-increasing need for a well-structured and readily accessible patient data, together with the rapid advancement in computer science. Computer-based records have the advantage of improved structure, legibility and accessibility.

One of the earliest efforts towards electronic medical record is at the orthopaedic clinic of Heidelberg University, Germany (Kramer K.L, Arbogast M, 1999). It was started in 1967 under 4 different phases starting with the first stage of medical doctors initiative, establishment of a basic documentation for scientific purposes, strategic information system planning and realization of information system. The basic documentation collects patients' basic data such as demographic data, diagnosis and treatment. It was initially recorded on paper but since 1972 it was transferred into computer (An IBM 360-30 mainframe computer). By 1973 around 800 clinics in Germany had already begun electronic data processing. The initial database was developed further over the years to become a complete electronic medical record not only for orthopaedic surgery but all other disciplines as well. There are now laboratory information systems, Tumour databank, Emergency

Care and Picture Archiving and Communication Systems in place.

At present the clinic, which has 320 beds and 1000 workers, is using 300 fast personal computers as client connected to about 20 servers. With their implementation of electronic medical record, the goal of structured and easily accessible patient data is realized. The move toward standardization was also achieved with the German government's regulation for standardization in medical record. The present patient database also supports prospective study. One of their studies that are going on is on the complication of orthopaedic surgery.

There are other systems developed around the same time in other parts of Europe and USA. Some of these elaborate systems are still being used. These includes COSTAR® (The Computer Stored Ambulatory Record System developed by the Massachusetts General Hospital in the 1970s, The Medical Record (TMR®) at Duke's University in 1974, STOR an early computer-based patient record developed at the University of California, San Francisco.

Earlier databases lack standardization (Solovitz P, 1995, Gerald I.W, 1995, Dick *et al* 1997). In order to achieve one of the goals of an electronic medical record system, i.e. exchange and sharing of patients' data among care providers and interested parties; a standard has to be defined. There are a lot of movements toward standardization globally. The *International Classification of Diseases* (ICD), which is published by the World Health Organisation, is designed to promote international comparability in the collection, processing, classification, and presentation of mortality statistics. The latest revision is now ICD-10. For oncology there is ICD-O, which has been used for the last 25 years and now in the third edition. Other Standard includes SNOMED (Systematized Nomenclature of MEDicine) and Health Level 7.

These different standards serve different purposes and complementary to each other. For an electronic medical records a few set of guidelines has been developed. Among them is the European Good Electronic Health Record. The Good European Health Record was a three-year project within the European Health Telematics research programmme (Advanced Informatics in Medicine) 1991-1995. It has developed comprehensive multimedia data architecture for using and sharing electronic healthcare records, meeting clinical, technical, educational and ethico-legal requirements. The GEHR project consortium involved 21 participating organisations in seven European countries, and included clinicians from different professions and disciplines, computer scientists in commercial and academic institutions, and major multi-national companies.

With the implementation of standards and guidelines, communication between different systems is possible and can be automated. There are a few electronic medical record systems developed adhering to these standards and guidelines. In Europe, for instance, during the last few years medical institutions in eight countries have been involved in the project known as I4C (Integration and Communication for the Continuity of Cardiac Care). The purpose is to provide seamless patient care by integrating patient-record data, images and videos, and biosignals, regardless of where the data have been processed or where they were stored. The core of the project is a generic patient-record system called ORCA (Open Record for Care), which presents data in a uniform, windows-based user interface. This approach towards a virtual patient record leaves all existing databases and applications unchanged. In principle, data from existing industrial or legacy systems can also be integrated without modification. (Bemmel, J.V, 1999).

For now, there are many large commercial electronic medical record systems for physicians to select from and an equally large number of hospital, managed care, and other organizational information systems with partial or complete medical keeping modules.

Many experts view the World Wide Web (www) as a plausible medium for those medical record systems that need to mediate between two or more heterogeneous databases, that seek to speed up processing by redistributing a significant proportion of the workload from the server to the user's computer, that present different views of the same data to different users, or that attempt to tailor information to the needs of individual user; all ideal features for any electronic medical record system. (Larzof M, 1998)

Among the systems are Stanford Hospital Record Electronic Web Documents (SHREWD), which was created in 1996 by James Cook as a prototype medical record and hospital information system using the World Wide Web and existing browser technology. It is a text-based interface with all the basic patient data accessible through the web.

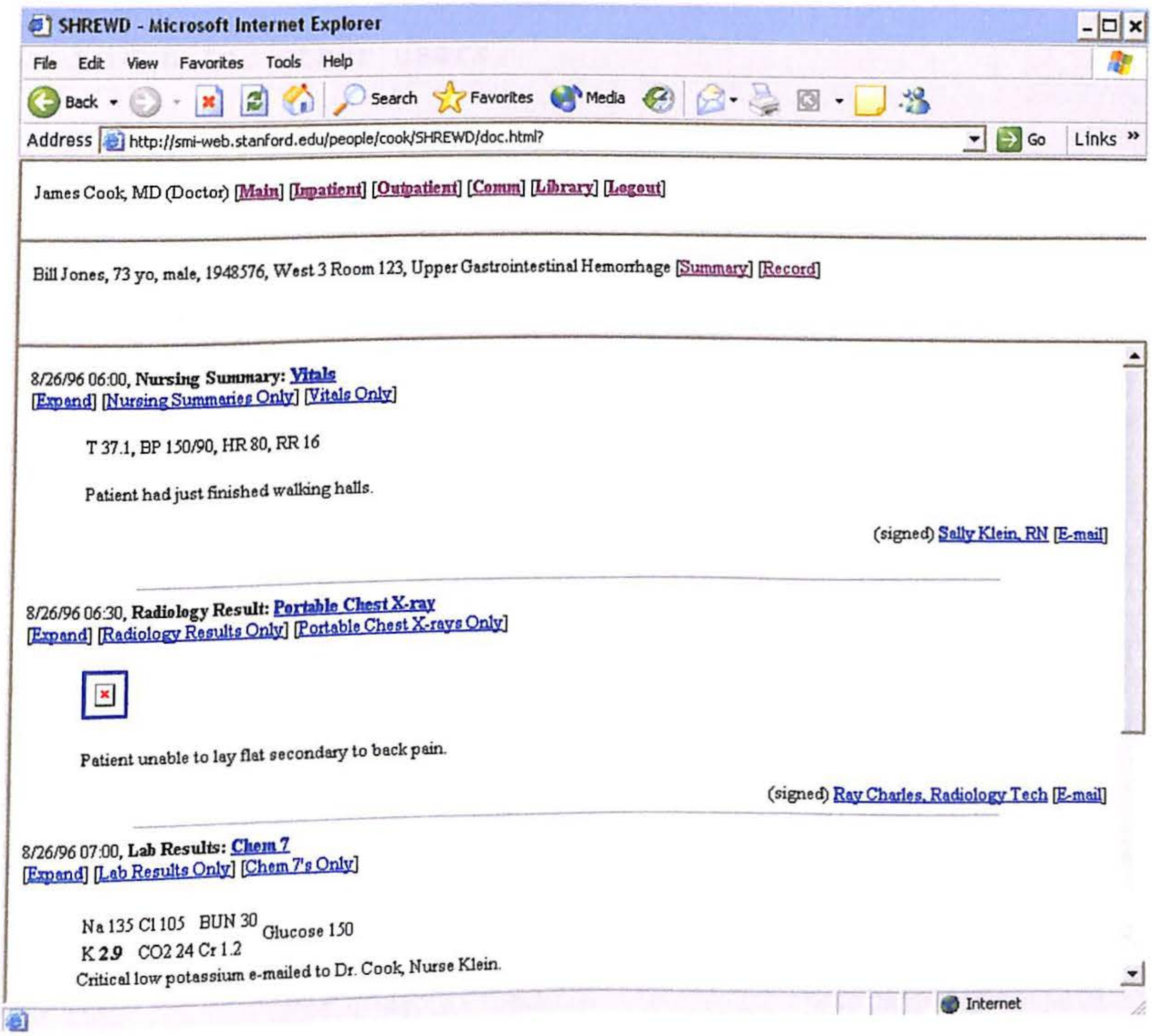

Fig 2.5 A sample demo page from SHREWD

There are also a good number of free web-based EMR under the open resource concept such as FreePM.

Web based electronic medical record system is good at accessing small amounts of data. For multimedia data such as high-resolution photos and video, a high-speed connection has to be in place before it is feasible. Delivering multimedia data through the present Internet connection that is currently available will clog up the bandwidth for other users.

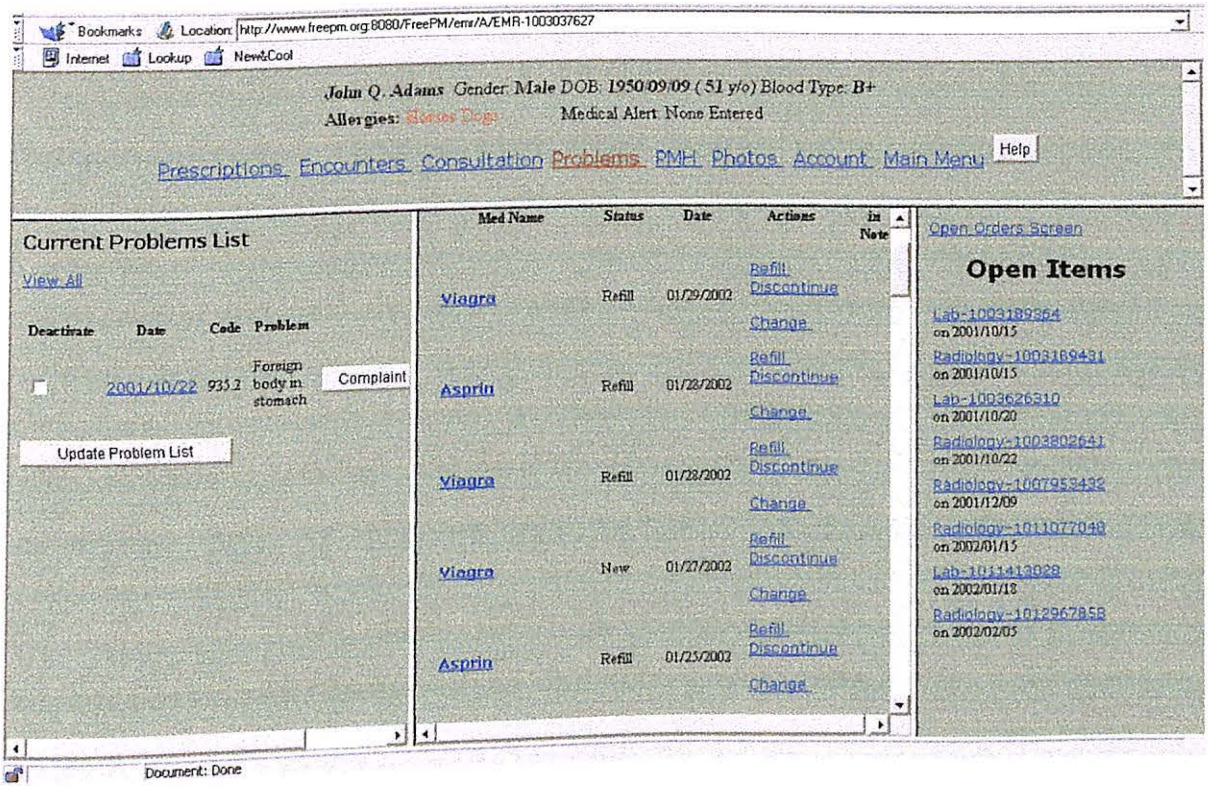

Fig 2.6 A sample screen shot of FreePM web-based EMR (http://www.freePM.org:8080/FreePM/emr/A/EMR-1003037627)

2.3 The multimedia database

Multimedia databases were initially developed to cater for the increasing number of images, which exploded with the introduction of the internet. As more and more digital devices were developed to produces images, the older method of storing data has to be revised. Image data contains lots of non-textual information that takes up a lot of space for storage. The problem associated with storing and retrieving of this type of data became apparent. Besides taking up a lot of space, these data types also take a long time to be retrieved, transmitted and displayed. To overcome this problem, one of the solutions is to compress the original file for storage and reconstruct it upon retrieval. A lot of effort has been done on this process. In the medical field, new imaging modalities such as Computed tomography (CT) and Magnetic Resonance Imaging were introduced which produced a significant number of image data. Later on other types of multimedia data, such as video and sound, were also converted into digital format.

A few standards were developed to cater for an increasing number of new media file types. For still images a number of compression schemes were available. It can be broadly categorized into lossy and lossless compression. In the lossy compression, the original image is compressed and will lose some of the details upon reconstruction. Whereas, in the lossless compression scheme, the original image quality is maintained upon reconstruction. One of the most widely used compression standard is the Joint Photographic Expert Group (JPEG) standard. It has both lossy and lossless compression method. An image can be compressed up to 1000 time of the original size with little quality degradation. The latest version available currently is the JPEG2000 standard. For medical imaging the most widely used standard is Digital Image Communication For Medicine (DICOM). Several coding and compression standards are available for video data. The Motion Picture Expert Group (MPEG) is the most widely used standard. It has gone through several versions, MPEG1, MPEG2 and MPEG4.

Multimedia database for medical fields were initially developed to cater to the needs of radiological image archiving from the X-ray, MRI, CT, SPECT and various other forms of data imaging. Earlier implementation lacked standardization with no unification between different medical equipment and countries. Earlier computers were not networked and had different incompatible programs and operating systems. The establishment of an international format for medical information, such as DICOM and improvement of networks for computers and equipments, such as Local Area network and the Internet, enabled easier access to digital medical information in the near future. The creation of specialized networked multimedia database, especially designed for therapy and research, post-graduate education, and medical education is expected.

In most of the general medical facilities today, hardware such as medical equipments, computers, and network to link these equipment are insufficient. The software to manipulate these machines is also insufficient.

There are many databases developed for these purpose and one of them is the work by Oizumi *et al* (1996) at the department of neurosurgery, School of Medicine, Keio University.

Fig 2.7 showed a sample screen output from the work of Oizumi *et al* (Journal of International Computer Aided Surgery, June 1996)

The development of these systems progressed further, and new modalities and uses of these databases were introduced.