



Concept Categorization and Knowledge Organization in Specialized Databases: A Case Study

Neelameghan, A.: **Concept categorization and knowledge organization in specialized databases: A case study.**

Int. Classif. 18(1991) No. 2, p. 92-97, 6 refs.

Presents a case study of the application of principles of concept categorization and arrangement of ideas in a specialized database forming a component of an information system MEDIS + designed to support research, education and training in the medical/health sciences. MEDIS + consists of 3 main databases: MEDIS, IIS, CHEM. MEDIS is composed of 3 types of case history records of hospital patients - general, pituitary diseases, tumours. IIS is composed of 6 types of records - medical syndromes, profiles of persons, of institutions, of research projects and descriptions of events and bibliographical records. CHEM is composed of 2 types of records - description of physical and chemical properties of selected chemicals and description of toxicological properties of selected chemicals. Only the MEDIS component is discussed. The data elements/fields and their arrangement in MEDIS records are more or less parallel to those of the corresponding hospital case history records/sheets. These were selected/organized by specialists in the respective fields who are also among the users of the system. The categorization and arrangement of the groups of fields conform to the categorization and sequence that may be obtained by the application of the postulates and principles of the general theory of knowledge classification. Hence the usefulness of the latter in concept categorization and knowledge organization in specialized database/knowledge-base design - especially in the organization of ideas in the knowledge-base, in recognizing the inter-relationship among the ideas and linking them accordingly, in assisting users of the system to navigate more conveniently in the knowledge-base to zero-in on their specific areas of interest at the moment, and in presenting the retrieved information/concepts in a helpful sequence. Examples of complex queries that may be applied to the different databases are given.

(Author)

1. Introduction

1.1 Eric de Grolier

Eric de GROLIER recognized, several decades ago, the usefulness of categorization of concepts and knowledge organization in information systems, for example, through applications of the theories and principles of knowledge classification. He has made distinctive contributions to this area as evidenced in his writings and teaching (1). From early days he was quite interested in, though may not be in full agreement with, the ideas of S.R.Ranganathan of India regarding concept categorization and knowled-

ge organization. In 1975, at the International Conference on Ordering Systems held in Bombay, Eric de Grolier paid handsome tributes to S.R.Ranganathan's contributions.

1.2 Knowledge Organization in Computerized Information Systems

With the increasing sophistications and capabilities of information technology hardware and software, categorization of concepts and organization of knowledge are found to be particularly helpful in specialized information systems, such as knowledge-based and expert systems, for example, the PLEXUS Project (2, 3). These may be used in organizing concepts in the knowledge-bases, for recognizing the inter-relationships among the concepts and in linking them accordingly, in assisting users to browse/navigate more conveniently in the knowledge-base, to zero-in on the specific areas of interest to them at the moment, and for presenting the retrieved records/ideas/information in a sequence helpful to users. Technology enables also the use of complex search expressions and the selection of relevant records interactively and with speed.

The construction and development of such information systems require on the part of the system designers a good knowledge of the subject of the knowledge-base as well as familiarity with concept categorization and knowledge organization, such as theories and principles of knowledge classification. It calls for close interaction between system designers and end-users or information users if the latter are not already involved in the designing and development of the system or if the designers do not adequately represent end-user groups.

1.3 Scope of the Paper

This paper presents briefly the application of concept categorization and knowledge organization in a specialized database that forms a constituent of an information system. This data base is a component of MEDIS +, an information system for supporting research and education in the medical/health sciences.

2. Information Content of Databases

Researchers, research administrators, teachers, and

students of medical/health sciences require a range of information of different types often concurrently even in specialized fields. MEDIS+ contains several types of information records integrated into 3 main data bases: MEDIS, IIS, and CHEM. Only the design of the MEDIS database is discussed in this paper. The prototype described is derived from existing operational systems for specialized medical subjects. Information records of MEDIS+ are identified as follows:

	Records relating to	Identifier	Database
01	Case histories of hospital patients (general)	PREMA	MEDIS
02	Case histories of patients with pituitary diseases	PITU	MEDIS
03	Case histories of patients with tumours	TMR1	MEDIS
04	Descriptions of selected syndromes	SYNDRO	IIS
05	Profiles of persons (specialists)	PER	IIS
06	Profiles of institutions	INST	IIS
07	Descriptions of research projects	PRO	IIS
08	Records of events (exhibitions, conferences, etc.)	EVENT	IIS
09	Bibliographical records.....	DOC	IIS
10	Descriptions of physical/chemical properties of selected chemicals	CHEM	CHEM
11	Descriptions of toxicological properties of selected chemicals	TOXIS	CHEM

3. Searching and Queries

3.1 Multiple Databases Searching

The system has been developed using the Unesco software micro-CDS/ISIS version 2.3. A search expression can be applied successively to the three data bases to retrieve different information records. For example, the query on

CARBON DISULFIDE POISONING IN WELDING WORKS

applied to MEDIS will retrieve PREMA records of patients who had been admitted to the hospital for treatment of carbon disulfide poisoning. The same query applied to CHEM (by simply changing the database and reexecuting the earlier query) will retrieve records detailing the pharmacology/toxicology of carbon disulfide (TOXIS records) and records on the chemical and physical properties, and chemical analysis and identification of carbon disulfide (CHEM records). The same query reexecuted on IIS database will retrieve bibliographical records on the subject and if there are records in the database profiling institutions specializing in carbon disulfide or gas poisoning, projects and experts in the subject, those records will also be retrieved.

Similarly, the query

SURGICAL TREATMENT OF TETRALOGY OF FALLOT

applied to MEDIS will retrieve all PREMA patients' records on the subject. The same query reexecuted on database IIS will retrieve all documentary records on the subjects and description of Tetralogy of Fallot from the SYNDRO records.

Index-based, thesaurus-assisted, free-text searches or a combination of these are possible. Search terms can be applied to specific fields of the database(s). Use of Boolean and other operators, terms adjacency, truncation, etc. are provided for. Also, context-sensitive search expressions can be used. Data on the number of cases and percentage of cases to the total can also be obtained.

Sample Queries

Sample queries to PREMA records

In which cases, in how many cases, and in what percentage of the total cases, e.g.

- incidence of cardiac infarction among Hindu males and females in the age group 25-45 years?
- of congenital cyanotic disease with right bundle branch block for which cardiopulmonary bypass was done?
- death occurred following surgical treatment of Fallot's tetralogy?
- of mitral stenosis with modular thickened cusps and positive diastolic thrill?
- of carbon disulfide poisoning in rubber vulcanising work?

Sample queries to PITU records

In which cases, in how many cases, and in what percentage of the total cases, e.g.

- postoperative deterioration of vision was noted?
- had second transphenoidal?
- of prolactinoma with high level prolactin, immunochemistry negative for prolactin secreting tumours?
- death following craniotomy?
- of optic atrophy and bilateral field defect in males above 25 years?

Sample queries to TMR1 records

In which cases, in how many cases, and in what percentage of the total cases

- of astrocytoma patients complained of temporal headaches, visual disturbances and hearing disturbances?
- of glioma or glioblastoma has previous CNS surgery?
- of acoustic nerve tumours showed 8th bilateral nerve deafness, abnormal spinal motor, abnormal gait and third ventricle delayed, periventricular lucency absent, single tumour in CT scan of head?

4. Fields and Knowledge Organization in MEDIS

The MEDIS database was constructed mainly by subject specialists, doctors/surgeons, especially in the speciali-

zed fields of tumours and pituitary diseases. These specialists are also among the users of the system. They received only a short training and some guidance in the use of the software. The data elements and their broad categorization and organization are more or less parallel to those of the patients' hospital case sheet. The broad categories of fields of a patient's record are:

- Patient's identity and administrative information (e.g. name, identification numbers, file reference, address, contacts, date of birth, age group, sex, blood group, dates of admission and discharge, personnel/doctor on duty when patient was admitted, hospital ward number, bed number, etc.)
- Patient's general background (e.g. religion, community, education, economic class, residence, occupation, work environment, etc.)
- Complaints of the patient
- Signs and symptoms observed
- Interrogation findings (e.g. personal history, family history, social history, social worker's data, house officer's notes, etc.)
- Investigations/examinations
- Treatment
- Follow-up, progress, complications, prognosis
- Recurrence, re-admission, treatment, progress.

This organization of the content of the patient's record is reflected in the Field Definition Table, in the online worksheet and in the display format(s) as desired by the users.

In each of the above categories/groups, the recorded information is divided into subunits and each of the latter again subdivided further as decided by the specialists. For example:

INVESTIGATIONS/EXAMINATIONS

General	
NMR	
Head CT scan	
Skull x-ray	
Cardiovascular system	
ECG	
Four vessel angiogram	
Carotid angiogram	
Ventriculogram	
Respiratory system	
Chest x-ray	
Pneumoencephalogram	
Hormones and levels	
Growth hormone	
T3	
T4	
TSH	
ACTH	
LH	
FSH	
Cortisol	
Testosterone	
Nervous system	
CT scan spine	
Muscular system	
Myelogram	

Similarly, under Signs and Symptoms, there is a long list of signs and symptoms grouped and arranged by the subject specialists.

The content of each field is specific; for example, each sign or symptom and each type of investigation constitutes a separate field. Initially all signs and symptoms were entered in one field and so it was with investigations. Although any concept/term in a field can be accessed either through the inverted file or through free text search, the subject specialists needed to know, for example, whether

- a particular symptom was present or not present in a particular case or set of cases and, if present the details;
- a particular surgical procedure was done or not done in a particular case or set of cases and, if done, the details.

And so on.

To such cases, the response has to be first 'Yes' or 'No' and if Yes then the details are to be displayed. Secondly the database record was required to be a mirror image of the case sheet of the patient and this facilitated data entry.

5. Display of Records

The information contained in the retrieved records can be presented in different segments. For example:

- the fields relating to signs and symptoms only
- the fields relating to the investigations only
- the fields relating to treatment and followup only
- the fields relating to administrative information only
- or a combination of these segments.

And in each display the fields can be arranged according to user preference.

The data in a patient's record can be distributed in two or more records, for example, a part record containing fields relating to identification & administrative information about a patient; another part record containing fields relating to patient's complaints, signs/ symptoms, investigations & diagnoses; another part record containing fields relating to treatment and follow-up. In the display, the part records can be linked as desired.

6. Thesaurus-like Facility for Selecting Concepts

A thesaurus-like facility is provided to facilitate navigating through the fields of record for a new user. This PASCAL interface suggests, in the first screen, that the user enters the term CASE; the system will then display the broad categories of fields into which the information content of patients records are divided (see Section 4):

CASE

SN Patient case history divided into the following
searchable areas
NT Administrative information
NT Complaints
NT Interrogation
NT Investigations
NT Signs and Symptoms
NT Treatment

Cues in the submenu at the bottom of the screen enables the user to select a specific area, for example, 'Investigation' and then more specific concepts under Investigation:

INVESTIGATION

- BT Case
- NT Angiogram
- NT Blood
- NT Cardiovascular system
- NT CT scan
- NT Hormones
- NT Myelogram
- NT NMR
- NT x-ray

CT SCAN

- BT Investigation
- NT Compressed
- NT Dilated ventricle
- NT Head
- NT High attenuation
- NT II ventricle
- NT III ventricle
- NT Intrasellar
- NT Parasellar
- NT Spine
- NT Suprasellar

ANGIOGRAM

- BT Investigations
- NT Carotid angiogram
- NT Carotid shift
- NT Four vessel angiogram

X-RAY

- BT Investigation
- NT X-ray chestm
- NT X-ray skull
- NT X-ray spine

X-RAY SKULL

- BT X-ray
- NT Abnormal
- NT Sella Gr.I
- NT Sella Gr.II

HORMONE

- BT Investigation
- NT ACTH
- NT Cortisol
- NT FSH
- NT LH
- NTT3
- NTT4
- NT Testosterone
- NT TSH
- RT Prolactin

Any or all of the terms can be selected to formulate search expressions applied to the database. This thesaurus-like tool contains terms selected from appropriate fields of the case records organized as in a thesaurus.

7. Sequence Preferred by Specialists

As the data elements were selected and categorized/grouped and arranged/organized by subject specialists/doctors/surgeons who are also users of the system, the categorization and organization of the information in the records are deemed to be helpful to specialist users. It is worth noting that the grouping of fields and the organization among coordinate fields appear to conform to the principles of helpful sequence of the general theory of knowledge classification (4, 5, 6). The specialists did not have any previous exposure to the theory of classification or principles of helpful sequence. And yet, the specialists' preferred sequence parallels that implied in the principles of helpful sequence of the general theory of classification. In other words, the latter makes explicit the sequencing of ideas in the thinking process of specialists and therefore provides general guidance for the consistent and helpful organization of ideas in a knowledge-base.

References

- (1) Grolier, Eric de: A study of general categories applicable to classification and coding in documentation. Paris: Unesco 1962.
- (2) Vickery, A., Brooks, H.M., Vickery, B.C.: An expert system for referral: the PLEXUS project. In: Davies, Roy. (Ed.): Intelligent information systems: Progress and prospects. Chichester: Ellis Horwood Ltd.19986. p.154-183
- (3) Vickery, A., Brooks, H., Bruce, R.: A reference and referral system using expert system techniques. J.Doc. 43(1987)p.1-23
- (4) Vickery, B.C.: Knowledge representation: a brief overview. J.Doc. 42(1986)p.145-159
- (5) Ranganathan, S.R.: Prolegomena to library classification. 3rd ed., Bombay: Asia Publ.House 1967 (Reprint 1990, available through UBSPD and INDEKS Verlag)
- (6) Neelameghan, A.: Presentation of ideas in technical writing. New Delhi: VIKAS 1975.

Annex

Query to PITU records: In which cases, in how many cases and in what percentage of cases

X-RAY SKULL ABNORMAL, CT SCAN INTRASELLAR, PROLACTIN LEVEL NOT LESS THAN 50, CONSCIOUSNESS LEVEL NOT LESS THAN 15 AND TRANSETHMOIDAL SURGERY AND TRANSPHENOIDAL

Search expression:

? val(v210)>=15 and val(v260)>=50 and v320:'abnorm' and v330:'intrasel' and v350:'transethmo' and v352:'y'

Response:

7 hits out of 44 records, 15.91%

Query to PITU records: The above query + DIABETES INSIPIDUS AS A POST-OPERATIVE COMPLICATION

Search expression:

? #1 v370:'diabetes insip'

Response:
1 hit in 44 records, 2.27%

Note: In the display of this record, the names of the hospital and of the department as well as the name of the patient and some other details of the case are not displayed for reasons of confidentiality.

xxxxxxxxMEDICAL CENTRE
DEPARTMENT OF.....

Name	:	xxxxxxxxxx
Age	:	28 ys.
Sex	:	Female
Case No.	:	538/88
Address	:	34A Metcalfe Street, Calcutta-13
Admission	:	19.08.88
Discharge	:	04.09.88
Surgery	:	24.08.88
Endocrine symptoms	:	Yes
Endocrine hyperfunc	:	Hyperprolactin
Visual disturbances	:	No
Headache	:	Yes. Temporal
Vomiting	:	No
Visual acuity right	:	6/6
Visual acuity left	:	6/6
Cranial nerve palsy	:	No
Consciousness (GS)	:	15
Higher functions	:	Normal
Hemiplegia	:	No
Cerebellar signs	:	No
Apoplexy	:	No
Prolactin	:	71
Growth hormone	:	1.4
X-ray skull	:	Abnormal; Sella Gr.II
CT scan	:	Intrasellar; Suprasellar
Surgery	:	Transethmoidal
Transphenoidal subtotal	:	Yes; Septum soft; Normal gland seen;
Postoperative compl.	:	Diabetes insipidus
Treatment recur.Med.	:	Bromocriptine
Treatment recur.DXRT.	:	No

Query to PREMA and CHEM records:

CASE RECORDS AND CHEMICAL ANALYSIS AND TOXICITY OF CARBON DISULFIDE

The search was made on the index file.

Responses:

Patient records (PREMA): 2; CHEM records: 1; TOXIS record: 1.

Example of PREMA record retrieved:

HOSPITAL	:	xxxxxxxxxx Hospital
DEPARTMENT	:	xxxxxxxxxx Department
HEAD	:	Dr.xxxxxxxxxx
PATIENT TYPE	:	Inpatient
NUMBER	:	86/43605
NAME	:	K.V.xxxxxxxx
ADDRESS	:	341/6 Taragupet, Bangalore
SEX	:	Male
AGE	:	48 ys.
ADMITTED ON	:	86.03.12. 1430 hrs
Discharged	:	Relieved. 86.03.18
COMPLAINTS	:	Headache. Shortness of breath; cough productive of mucoid sputum
FINAL DIAGNOSIS	:	Carbon disulfide inhalation
EXAMINATION	:	Hemocrit 39 p.c.; WBC 16,400/mm ³ with 73 p.c. neutrophils, 17 p.c. bands, 5 p.c. monocytes, 3 p.c. eosinophils, 2 p.c. basophils
ETIOLOGY	:	Inhalation of toxic gases
PROGRESS REPORT	:	Patient continued to have malaise, mild cough and weakness following discharge

Toxicity of Carbon Disulfide

0011

CARBON DISULFIDE

CATEGORY: SOLVENT

ALTERNATIVE NAMES: Carbon bisulfide

OCCURRENCE/USE: Rubber vulcanization. Vulcanization. Welding. Artificial silk. Rayons. Solvents. Defatting agent. Insecticide. Rodenticide.

CHEM.PROPERTIES: For more details use CHEM data base. Colourless or yellow, odorous, flammable liquid. BP 46-47xC. Dissolves sulfur.

SIGNS/SYMPOTOMS: Nausea, vomiting, diarrhea, abdominal pain, pulmonary edema, convulsions, collapse, coma, death. Chronic: dizziness, weakness, vertigo, visual disturbances, hysteria, nervous disorders, pains in limbs, paralysis with tremors, mental disorders, psychoses.

EXPOSURE: Inhalation

MLD: Approx 10 ml for a 150-pound person.

METABOLISM/TOXICITY: Predominant nervous system effects of overexposures are psychosis, tremor and polyneuritis. The condition resembles thiamine deficiency and responds to thiamine injection. Extrapyramidal signs, chorea and athetosis may be related to the lesion of the corpora striata.

INFLUENCING FACTORS: For a checklist of influencing factors use ACTORS data base.

IDENTIFICATION: Urine analysis. For details of identification use CHEM data base.

TREATMENT: Remove from the exposure: emetics and gastric lavage if ingested. Administer oxygen as soon as possible; artificial respiration if needed. Treat pulmonary edema. Keep patient warm and quiet. Short-acting barbiturates with caution for sedation. Blood transfusion if indicated. Fluid therapy (carefully) and other supportive measures. Antibiotics prophylactically.

REFERENCES: Kaye, Sydney / Handbook of emergency toxicology / 3rd ed / 1971. Casarett, Louis J.; Doull, John / Toxicology : The basic science of poisons / 1975.

Chemistry of Carbon Disulfide

*** CARBON DISULFIDE ***

ALTERNATIVE NAME(S): Carbon bisulfide; Dithiocarbon anhydride.

CATEGORY: Solvent.

MOLECULAR FORMULA: CS₂.

MOL.WT: 76.14

PHYS/CHEM.PROPERTIES: Minute amounts occur in coal tar and in crude petroleum. Prepared on industrial scale by heating charcoal with vapourised sulfur; from sulfur and natural gas. Colourless or yellow, highly refractive odorous, very inflammable liquid; BP 46-47xC. Pure distillates have sweet, pleasing, ethereal odour. Burns with a blue flame to CO₂ and SO₂. Flash point, closed cup-30xC. Ignition point 100x. Miscible with anhydrous methanol, ethanol, ether, benzene, chloroform, carbon tetrachloride, oils.

IDENTIFICATION: Separated by steam distillation; second fraction contains most. (1) Add Fehling's solution to 10 ml of urine and boil giving grey precipitate. (2) To 10 ml (second distillate), add 5 drops of formaldehyde, 7 drops of 30 p.c. KOH, 3 drops of 10 p.c. lead acetate giving creamy to black colour or precipitate. Sensitive to 0.1 mg per 10 ml. (3) Gently heat 10 ml of distillate plus 2 ml of ammonia and 2 ml of alcohol. Add 3 ml of HCl and 1 ml of ferric chloride (10 p.c.) giving red colour. (4) Alcoholic potassium hydroxide, neutralize with acetic acid, add copper sulfate (10 p.c.) to yellow precipitate (copper xanthate). (5) Harrow and Wiley method: see Journal of Industrial Hygiene and Toxicology 19;1937;486.

REMARKS: Used in the manufacture of rayon, carbon tetrachloride, xanthogenates, soil disinfectants, electronic vacuum tubes. Solvent for phosphorous, sulfur, selenium, bromine, iodine, fats, resins, rubbers.

REFERENCES: Kaye, Sydney / Handbook of emergency toxicology / 3rd ed / 1971; Merck index / 10th ed / 1983.

Query to IIS and SANDRO records: MOYA MOYA DISEASE

Response: IIS records 2; SYNDRO record 1.

Moya Moya Disease

0036

Suzuki Ryuta; Matsushima Yoshiharu; Takada Yoshiaki; Narai Tadashi; Wakabayashi Shin-ichi; Tone Osamu. Changes in Cerebral Hemodynamics following Encephalo-Duro-Arterio-Synangiosis (EDAS) in young patients with Moyamoya Disease.

In: *Surg Neurol* 1989;31:343-9

ABSTR: To evaluate the effect of encephalo-duro-arterio-synangiosis, (EDAS), we obtained follow-up angiograms and measured regional cerebral blood flow in 21 young patients with Moyamoya disease. Carotid fork stenosis continued to progress after EDAS, although angiography demonstrated a marked increase in the number of middle cerebral artery branches via implanted arteries. Pre-operative cortical blood flow was lower than normal. The post-EDAS increases in hemispheric and cortical flow were significant in patients with transient ischemic attacks, but not in patients with infarction. The increase in cortical flow at the site of EDAS was first noted 3 weeks after EDAS.

KEYWORDS: Moyamoya disease, Cerebral blood flow, Cerebral angiography, Encephalo-dura-arterio-synangiosis, Pediatric neurosurgery.

0061

Grabel Jordan C.; Levine Mitchell; Hollis Peter; Ragland Ronald. Moyamoya-like disease associated with a lenticulostriate region aneurysm. Case report.

IN: *J Neurosurg* 70:802-803, 1989.

ABSTR: A case of moyamoya-like disease associated with an intracerebral hemorrhage and an unusual aneurysm is reported. The patient's clinical status and the initial and follow-up angiographic appearance of the aneurysm are presented. The etiology of the moyamoya phenomenon and of associated aneurysms is discussed.

KEYWORDS: Cerebral aneurysm, intracerebral hemorrhage, moyamoya disease, pseudoaneurysm.

Moya Moya Syndrome

SYNDROME

NAME: MOYA-MOYA syndrome

SYNONYM: Progressive arterial intracranial occlusions; Intracranial arteries progressive occlusions; Kawakita's syndrome; Leed's

syndrome; Maki's syndrome; Multiple progressive intracranial arterial occlusions; Taveras syndrome.

SYMPTOMS: Most cases in Japanese; a few Black races and Caucasian patients. Onset from infancy to adulthood, usually following some non-specific infectious process or cold.

INCIDENCE-SEX: M, F.

INCIDENCE-AGE: Infancy to youth.

SIGNS: Paralysis and focal epileptic attacks, alternating between both sides, together with twitching, speech disturbances, unsteady gait, hemianopia, and headache. In some cases especially adults, psychiatric manifestations which may be followed by signs of intracranial hemorrhage.

ETIOLOGY: Unknown; considered a non-specific inflammation due to autoimmune reaction.

PATHOLOGY: Occlusion of distal internal carotid artery and middle cerebral arteries, and sometimes basilar arteries and proximal posterior cerebral arteries. Absence of atherosclerotic changes.

DIAGNOSTIC PROCEDURES: X-ray: of skull usually normal. Angiography: Occlusion usually situated in internal carotid artery at its bifurcation; development of a large network of vessels in basal ganglia and upper brain stem areas from basilar artery and trunk of anterior and middle cerebral arteries. Marked degree of vascularization and visualization of rete mirabile. Spinal tap: Occasionally hemorrhagic.

THERAPY: Corticosteroids apparently not effective. Surgery for removal of obstruction attempted.

PROGNOSIS: Progress to complete obstruction of major arterial network along base of brain that eventually stops spontaneously. Majority of patients survive with moderate or no disability. Mental retardation in one-third of children.

REFERENCES: Kawakita, Y.: Abe, K; Miyata, Y. et al. Spontaneous thrombosis of internal carotid artery in children. (*Folia Psychiatr.Neurol.Japan.* 19;1965;245-255); Leeds, N.E.; Abbott, K.H. Collateral circulation in cerebrovascular disease in childhood via rete mirabile and perforating branches of anterior choroidal and posterior cerebral arteries. (*Radiology* 88;1965;628-634); Kudo, T. Spontaneous occlusion of circle of Willis; disease apparently confined to Japanese. (*Neurology* 18;1968;485-496); Taveras, J.M. Multiple progressive intracranial arterial occlusion. (*Amer. J. Roentgenol. Rad. Ther. Nucl. Med.* 106;1969;235-268).

SOURCE: DMS.

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