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# An analysis of diagnostic reasoning in clinico-pathological conferences

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AN ANALYSIS OF DIAGNOSTIC REASONING IN  
CLINICO - PATHOLOGICAL CONFERENCES

Jennifer Robinson Niebyl

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AN ANALYSIS OF DIAGNOSTIC REASONING

IN

CLINICO - PATHOLOGICAL CONFERENCES

by

Jennifer Robinson Niebyl

B.Sc., McGill University, 1963

A Thesis Submitted in Partial Fulfillment  
of the Requirements for the Degree of

Doctor of Medicine

Department of Internal Medicine  
Yale University School of Medicine

New Haven, Connecticut

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## I. INTRODUCTION

### 1.) The Clinico-pathological Conference

The current interest in the use of modern computers for diagnosis has prompted several recent studies of diagnostic reasoning.<sup>1-6</sup> To construct intellectual models for diagnosis requires a basic understanding of the diagnostic process and a knowledge of sources of error.

The clinico-pathological conference offers a unique opportunity to study the diagnostic process. In his discussion of each diagnostic problem presented at the clinico-pathological conference, the physician must delineate his ideas and justify his decisions. He cannot rely on probability alone, since uncommon disorders may appear as often as common ones among the case histories. Thus the discussor must present his reasoning, which can then be analyzed; and the validity of his conclusions is immediately confirmed or refuted by the pathologist's report.

Certainly there are limitations in the use of clinico-pathological conference discussions for studying diagnostic reasoning: the discussor knows that the patient has died or has undergone a surgical procedure; the cases are not a general selection of human disease, and the data available are only those written into the record. Nevertheless, the clinico-pathological conference has assumed a major role in teaching diagnostic reasoning to students today. In particular, the published clinico-pathological conferences of the Massachusetts General Hospital are a source of diagnostic discussions by expert physicians, and are models often emulated by students and



practicing physicians alike. Therefore these clinico-pathological conferences were chosen as the subject of the present study.

As a teaching device, the clinico-pathological conference is of relatively recent origin. Dr. Walter B. Cannon, while still a medical student in the late 1890's, was apparently the first<sup>7</sup> American physician to suggest what he called "the case method" of teaching medicine. In 1900 he published a paper<sup>8</sup> urging that the study of real histories could be made feasible in medical education, and his suggestion led directly to the development of the Cabot clinico-pathological conferences at the Massachusetts General Hospital.<sup>7</sup>

Dr. Richard C. Cabot was one of the first to use printed case histories in weekly teaching exercises. In 1910 he added the autopsy report to the clinical summary, and thus started clinico-pathological conferences in their present form.<sup>9</sup> From 1915 to 1923 they were printed separately as the Case Records of the Massachusetts General Hospital, and subsequently were published in the Boston Medical and Surgical Journal (later the New England Journal of Medicine). Through their weekly publication in this journal, the clinico-pathological conferences have become a popular exercise.

## 2.) Previous Studies Comparing Clinical and Pathological Findings

In a study of clinico-pathological conferences at the Massachusetts General Hospital, Hunter<sup>9</sup> listed the eleven diagnoses most commonly missed between 1923 and 1948. He found that the leaders on the list were aortic and mesenteric vessel disease, carcinoma of the pancreas and colon, subacute bacterial





endocarditis, and the lymphomas. He reviewed the variability of the clinical picture presented by these diseases, but he did not describe the types of cases presented and did not analyze the errors in diagnosis.

Other studies<sup>10,11</sup> comparing clinical and pathological findings in autopsy cases have described specific errors in diagnosis, rather than general sources of error, procedures in reasoning, and intellectual types of error.

Munck<sup>10</sup> compared autopsy findings with clinical diagnoses in 1000 cases in Denmark in 1952. He classified the clinical diagnosis as: (1) "correct", if both the nature and the localization of the principal disease were diagnosed correctly; (2) "almost correct", if either the site or the nature of the disease were diagnosed correctly and the other incorrectly; (3) "inadequate", if essential disagreement existed between the clinical and pathological diagnoses; or (4) "incorrect", if the principal disease were not diagnosed at all. He found that 79.7% of clinical diagnoses were correct, 8.7% almost correct, 4.9% inadequate, and 6.7% incorrect. Diseases in which diagnostic difficulties were most often encountered were primary malignant tumors, coronary thrombosis, pulmonary embolism, cerebral hemorrhage and pulmonary tuberculosis. He noted that certain conditions (e.g. coronary thrombosis) which had not been evident clinically were often found at autopsy. He thus pointed out specific discrepancies between clinical and autopsy findings, but he made no attempt to delineate the sources of error in diagnosis.

Gruver and Freis<sup>11</sup> reviewed 1106 autopsies done between 1947



and 1953 in Washington, D.C., and found that 6% of clinical diagnoses were incorrect. Infections, such as pneumonia and meningitis, were most commonly overlooked. The authors described several specific factors contributing to diagnostic errors. In 45% of cases diagnosed incorrectly, the patient was unable to give a history because of shock, coma, confusion, acute alcoholism or aphasia. Two types of "errors of omission" occurred because of: (1) failure to obtain admission screening tests (e.g. chest x-ray), which led to errors in diagnosis in 13% of incorrectly diagnosed cases; (2) failure to carry out an indicated procedure (e.g. lumbar puncture in a patient with fever and neurological abnormalities), which resulted in diagnostic error in 39% of incorrectly diagnosed cases. Three types of "errors of judgment" were described: (1) failure to account for a symptom or sign in 28% of incorrectly diagnosed cases; (2) failure to account for a laboratory, x-ray, or electrocardiographic abnormality in 25% of incorrectly diagnosed cases; and (3) maintenance of a prejudiced viewpoint in 16% of incorrectly diagnosed cases. (One common prejudice was the assumption that a previous diagnosis explained the present illness.) A falsely "normal" x-ray (an x-ray which failed to demonstrate an existing lesion) contributed to error in 13% of incorrectly diagnosed cases. Gruver and Freis concluded that diagnostic errors seemed to be due to deficiencies in medical judgment and thoroughness rather than lack of medical knowledge.

The present study was undertaken to determine some general characteristics and the accuracy of diagnosis of the published



cases presented at the clinico-pathological conferences of the Massachusetts General Hospital at different times during a span of four decades, and to analyze the sources and types of errors in diagnosis made in certain selected cases.

## II. METHODS AND MATERIALS

The reviewed material consisted of all the clinico-pathological conferences of the Massachusetts General Hospital published in the years 1922, 1942, and 1962. The clinico-pathological conferences presented in 1922 were published separately as the Case Records of the Massachusetts General Hospital, whereas the clinico-pathological conferences of 1942 and 1962 were published in the New England Journal of Medicine.

### 1.) General Categorization of Cases

Each case was categorized according to (1) clinical topic, (2) source of pathological data, (3) presence or absence of an anatomical lesion, and (4) accuracy of diagnosis.

#### (1) Clinical Topic

The cases were categorized clinically according to the patient's chief complaint at the time of his last admission. If no chief complaint were evident, the case was categorized according to the major diagnosis of the discussor, i.e., the physician discussing the case. Thus the cases were grouped according to the clinical picture which they presented, rather than according to pathological diagnosis, as in the previously mentioned studies. The categories of clinical topics were as follows: Cardiovascular-



respiratory, Gastroenterological, Genitourinary, Neurological, Hematological-lymphatic, Gynecological, Dermatological, Orthopedic, Metabolic, and Multi-systemic.

(2) Source of Pathological Data

The case was categorized as Autopsy if the discussor knew that the patient had died. The case was categorized as Surgical Pathology if the case history ended with the statement that an operation was performed or that a diagnostic procedure was undertaken. In the few cases in which the patient died during or after surgery but the death was not revealed until after the discussion at the clinico-pathological conference, the category of Surgical Pathology was used even if full autopsy findings were subsequently given.

(3) Presence or Absence of an Anatomical Lesion

When the "disease" was demonstrated as a morphologic lesion, the case was classified as Anatomical. When no etiological lesion was demonstrated by gross anatomic or microscopic examination (e.g. in some cases of diabetes mellitus or hyperthyroidism), the case was classified as Non-anatomical.

(4) Accuracy of Diagnosis

The discussor's major diagnosis (or diagnoses) was rated as correct, partly correct, or incorrect. The rating was Correct if all the discussor's major diagnoses were correct. The rating was Partly Correct if one of two major diagnoses, or a part of more than two major diagnoses, were correct. If there were two aspects of a major diagnosis (e.g. the site and nature of the





disease process), and only one aspect diagnosed correctly, the rating was also Partly Correct. If all the major diagnoses were incorrect, the rating was Incorrect.

## 2.) Separate Analysis of Cardiovascular-respiratory Cases

In addition to the above classifications, which were given to all of the cases studied, a further analysis was made of all the cases of the Cardiovascular-respiratory group.

Each Cardiovascular-respiratory case was classified as Clinical or Para-Clinical according to whether the discussor relied mainly upon evidence obtained by a routine history and physical examination, or whether the critical information was obtained by some para-clinical test or procedure, such as x-ray or laboratory analysis.

In those cases which were Incorrect or Partly Correct, an analysis of the type of error was made. The errors were classified as follows:

1. Errors of Omission occurred when the discussor failed to mention the correct diagnosis anywhere in his discussion. For example, in one case the patient had a firm thyroid nodule, and rapid progression of cough, dyspnea and cyanosis. Patchy confluent densities and a superimposed reticular pattern were seen on x-ray. The clinician diagnosed lymphangitic spread of thyroid carcinoma, and completely omitted the correct diagnosis, idiopathic interstitial fibrosis of the lungs or Hamman-Rich syndrome, from his discussion of the diagnostic possibilities.<sup>12</sup>

2. Errors of Inappropriate Exclusion occurred when the discussor felt that the correct diagnosis was incompatible with the



findings, and definitely ruled it out. For example, in the discussion of a febrile patient with laborious respirations, rhonchi and crepitations throughout the lungs and dullness over the right chest, the discussor ruled out tuberculosis on the basis of "repeatedly negative Pirquets and intradermal tests". The patient was found to have widespread tuberculosis, in the lungs, intestines, liver and spleen.<sup>14</sup>

4. Errors of Addition occurred when the discussor made the correct diagnosis, but felt obliged to add an extra incorrect diagnosis to explain the findings. For example, in a patient with cardiac murmurs and congestive heart failure, the discussor diagnosed syphilitic aortitis with aortic insufficiency, and congenital heart disease with a septal defect. The anatomical diagnosis was syphilitic aortitis with aortic insufficiency, but no congenital abnormality was found.<sup>15</sup>

### III. RESULTS

In 1922 there were 154 clinico-pathological conferences, excluding five cases which were presented for clinical discussion only, without autopsy data. There were 105 cases in 1942 and 86 cases in 1962. The frequency of cases published was approximately three per week in 1922, two per week in 1942, and one to two per week in 1962.

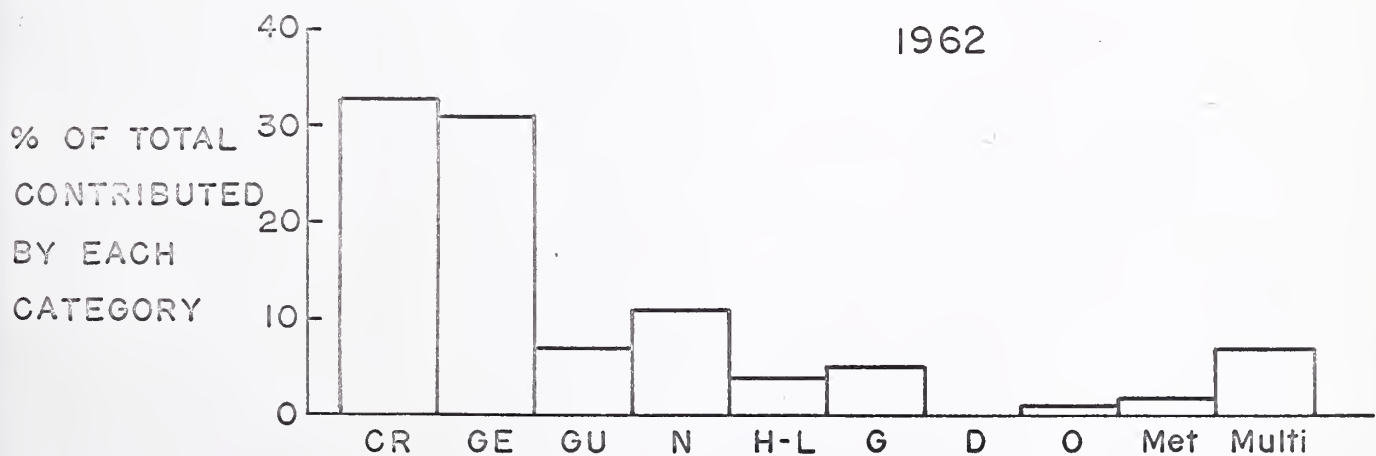
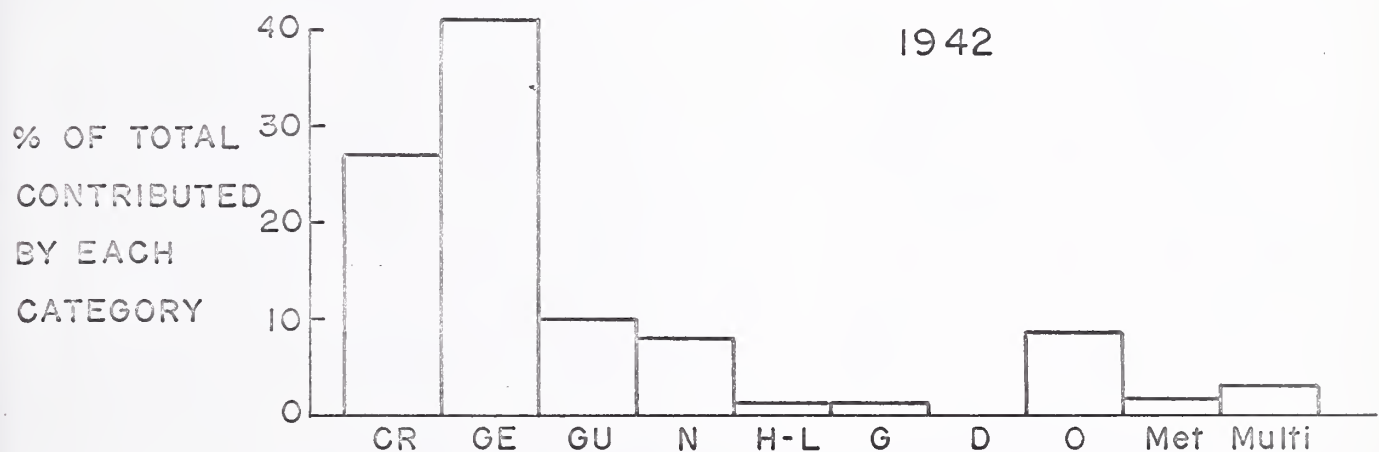
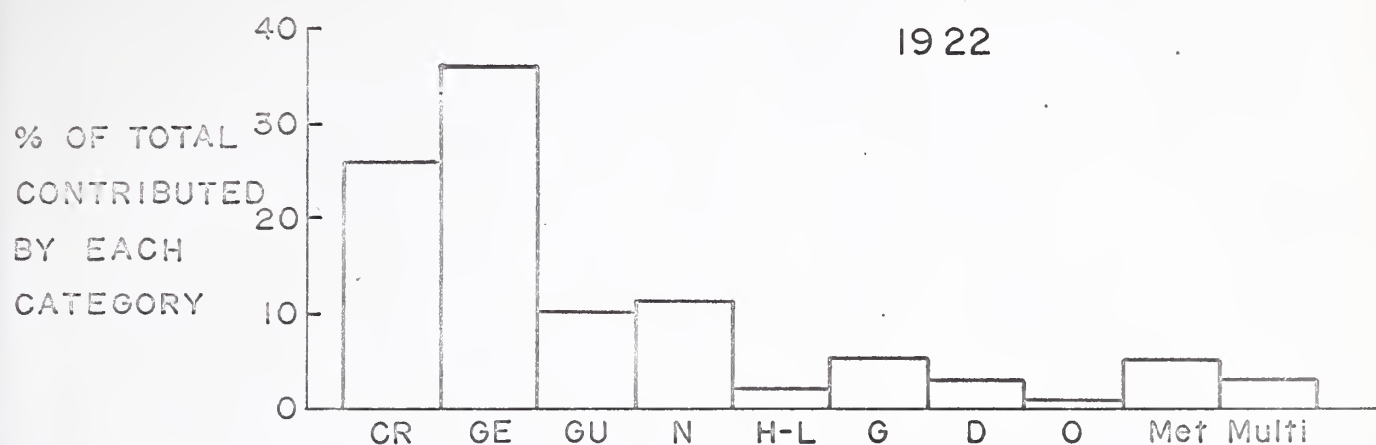
#### 1.) General Categorization of Cases

##### Clinical Topic

Figure 1 (p. 9) and Table 1 (p. 10) show the incidence of the types of clinico-pathological conference according to clinical topic for each year. Cardiovascular-respiratory and



FIG. 1 INCIDENCE OF TYPES OF CLINICO-PATHOLOGICAL CONFERENCE ACCORDING TO CLINICAL TOPIC



CR Cardiovascular-respiratory

GE Gastroenterological

GU Genitourinary

N Neurological

H-L Hematologic-lymphatic

G Gynecological

D Dermatological

O Orthopedic

Met Metabolic

Multi Multi-systemic



TABLE 1

Incidence of Types of Clinico-pathological Conference  
According to Clinical Topic

	Total	Cardio-vascular-respiratory	Gastro-enterological	Genito-urinary	Neurological	Hematolymphatic	Gynecological	Dermatological	Orthopedic	Metabolic	Multi-systemic
1922											
no.	154	40	55	15	17	3	7	4	1	8	4
% of total	100	26	36	10	11	2	5	3	0.6	5	3
1942											
no.	105	28	43	10	8	1	1	0	9	2	3
% of total	100	27	41	10	8	1	1	0	9	2	3
1962											
no.	86	28	27	6	9	3	4	0	1	2	6
% of total	100	33	31	7	11	4	5	0	1	2	7

TABLE 2

Proportion of Anatomical Cases

	1922	1942	1962
Total number of cases	154	105	86
Number of <u>Anatomical</u> cases	148	104	84
% <u>Anatomical</u> cases	96	99	98





Gastroenterological cases occurred most frequently, together accounting for more than half of the total cases each year. Next most commonly encountered were Genitourinary and Neurological cases, each of which accounted for about 10% of the total. The other categories each contributed only a small percentage of the cases. The general distribution of the types of cases presented has not changed over the forty year period.

Presence or Absence of an Anatomical Lesion

Despite changing techniques of diagnosis and increasing use of chemical methods for detection of disease over the period studied, the clinico-pathological conference has remained mainly an anatomical exercise. The percentage of Anatomical cases was 96%, 99% and 98% in 1922, 1942, and 1962, respectively (Table 2) (p. 10). The relative absence of cases that lack demonstrable anatomical lesions appears to be the main bias of the clinico-pathological conference as a means of studying diagnosis of different diseases in modern medicine.

Number of Cases, Accuracy of Diagnosis, and Source of Pathological Data

In Figure 2 (p. 12) and Table 3 (p. 13), findings are presented for each year for: (1) the total group of cases, (2) the four major categories (Cardiovascular-respiratory, Gastroenterological, Genitourinary, and Neurological), and (3) the sum of the six other categories combined as a group, Miscellaneous. The data presented are: a) number of cases, b) percentage of total cases in the year, c) percentage of cases diagnosed



FIG. 2 NUMBER OF CASES, ACCURACY OF DIAGNOSIS, AND SOURCE OF PATHOLOGICAL DATA

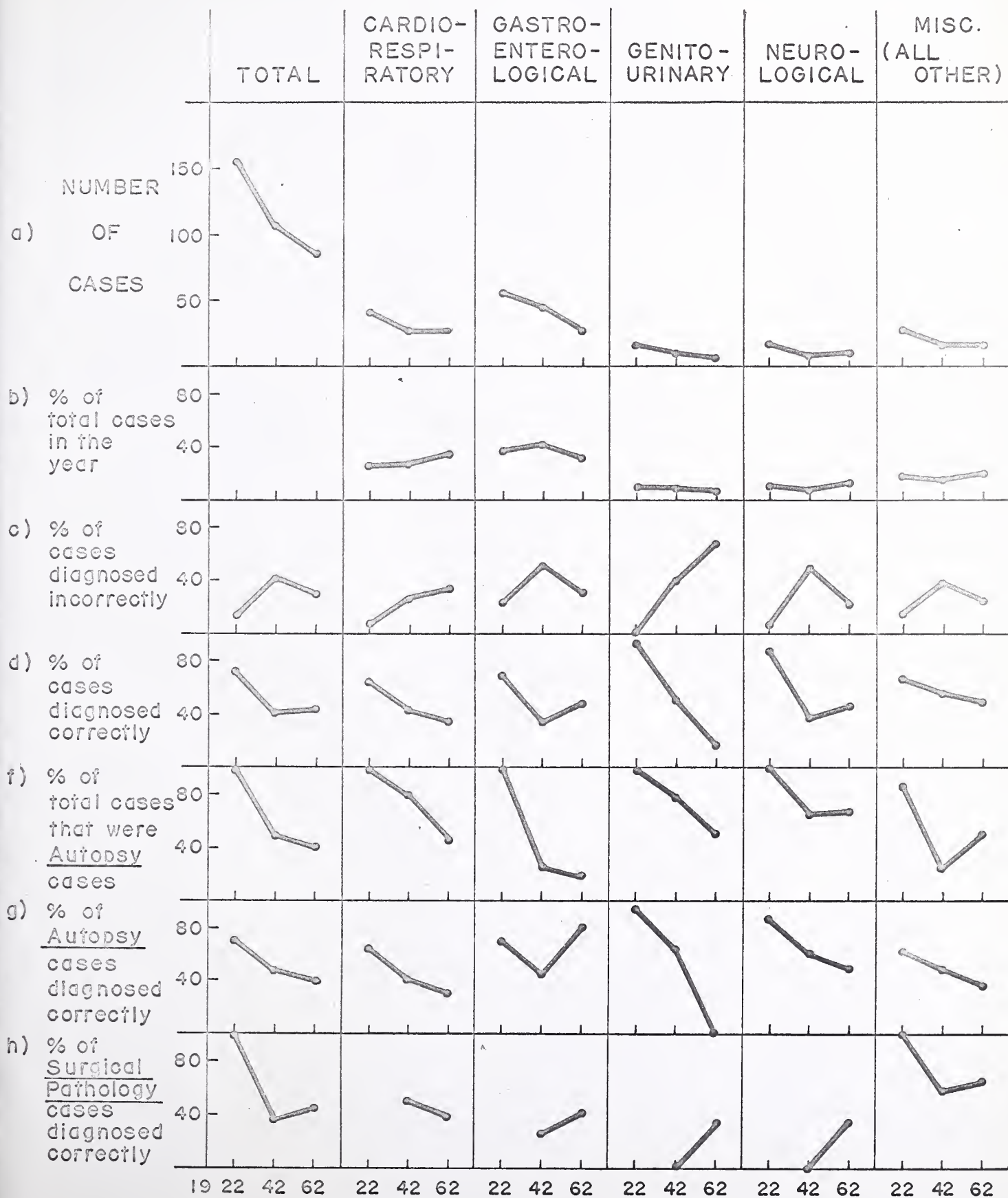




TABLE 3

Number of Cases, Accuracy of Diagnosis, and Source of Pathological Data

Year	Total			Cardio-respiratory			Gastro-enterological			Genito-urinary			Neuro-logical			Miscel-laneous					
	19:	<u>22</u>	<u>42</u>	<u>62</u>	<u>22</u>	<u>42</u>	<u>62</u>	<u>22</u>	<u>42</u>	<u>62</u>	<u>22</u>	<u>42</u>	<u>62</u>	<u>22</u>	<u>42</u>	<u>62</u>	<u>22</u>	<u>42</u>	<u>62</u>		
a) Number of cases	15	4	10	5	86	40	28	28	55	43	27	15	10	6	17	8	9	27	16	16	
b) % of total cases in the year	100	100	100		26	27	33	36	41	31	10	10	7	11	8	11		18	15	19	
c) Cases diagnosed incorrectly	No.	19	43	27		2	7	9	12	22	8	0	4	4	1	4	2		4	6	4
	% of total	12	41	31		5	25	32	22	51	30	0	40	67	6	50	22		15	38	25
d) Cases diagnosed correctly	No.	110	43	36		25	12	10	38	14	13	14	5	1	15	3	4		18	9	8
	% of total	71	41	42		62	43	36	69	33	48	93	50	17	88	38	44		67	56	50
e) Cases diagnosed partly correctly	No.	25	19	23		13	9	9	5	7	6	1	1	1	1	1	3		5	1	4
	% of total	16	18	27		33	32	32	9	16	22	7	10	17	6	12	33		19	6	25
<u>Autopsy Cases</u>																					
f)	No.	150	50	35		40	22	13	55	11	5	15	8	3	17	5	6		23	4	8
	% of total cases	97	48	41		100	79	46	100	26	19	100	80	50	100	63	67		85	25	50
g)	No. diagnosed correctly	106	24	14		25	9	4	38	5	4	14	5	0	15	3	3		14	2	3
	% of Autopsy cases diagnosed correctly	71	48	40		63	41	31	69	45	80	93	63	0	88	60	50		61	50	37
<u>Surgical Pathology Cases</u>																					
h)	No. diagnosed correctly	4	19	22		3	6		9	9		0	1		0	1			4	7	5
	% of S.P. cases diagnosed correctly	100	35	43		50	40		28	41		0	33		0	33			100	58	63



incorrectly, d) percentage of cases diagnosed correctly, e) percentage of cases diagnosed partly correctly, f) percentage of cases categorized as Autopsy, g) percentage of Autopsy cases diagnosed correctly, and h) percentage of Surgical Pathology cases diagnosed correctly. In Table 4 (p. 15) the numbers are given for each year for each of the six smaller categories.

a) Number of cases

In all the major categories and in the Miscellaneous group, the absolute number of cases decreased between 1922 and 1942. The number decreased further in 1962 in the Gastroenterological and Genitourinary categories, stabilized in the Cardiovascular-respiratory and Miscellaneous groups, and increased by one in the Neurological category. Dermatological cases appeared only in 1922 (4 cases). Metabolic cases decreased from 8 in 1922 to 2 in each of 1942 and 1962, reflecting mainly a decreasing presentation of cases with diabetes mellitus as the major diagnosis. (Five of the eight Metabolic cases in 1922 were cases with diabetes mellitus as the major diagnosis, while none in 1942 or 1962 were cases with this major diagnosis.) There were nine Orthopedic cases in 1942, but only one in each of 1922 and 1962.

b) Proportion of cases

The proportion of cases contributed by each major category remained fairly constant. The proportion contributed by Cardiovascular-respiratory cases rose slightly, and the proportion of Gastroenterological cases rose in 1942 and fell in 1962 to lower than the 1922 value. The rise in the proportion of Multi-systemic cases in 1962 reflects an increasing presentation of cases of the "collagen-vascular" diseases.





TABLE 4

Number of Cases, Accuracy of Diagnosis, and Source of Pathological Data

Year	19:	Hemato-lymphatic			Gyneco-logical			Dermato-logical			Ortho-pedic			Meta-bolic			Multi-systemic		
		<u>22</u>	<u>42</u>	<u>62</u>	<u>22</u>	<u>42</u>	<u>62</u>	<u>22</u>	<u>42</u>	<u>62</u>	<u>22</u>	<u>42</u>	<u>62</u>	<u>22</u>	<u>42</u>	<u>62</u>	<u>22</u>	<u>42</u>	<u>62</u>
a) Number of cases		3	1	3	7	1	4	4	0	0	1	9	1	8	2	2	4	3	6
b) % of total cases in the year		2	1	4	5	1	5	3	0	0	0.6	9	1	5	2	2	3	3	7
c) No. of cases diagnosed incorrectly		1	0	1	2	0	1	0	0	0	0	3	1	0	1	0	1	2	1
d) No. of cases diagnosed correctly		0	1	0	5	1	2	3	0	0	1	5	0	7	1	2	2	1	4
e) No. of cases diagnosed partly correctly		2	0	2	0	0	1	1	0	0	0	1	0	1	0	0	1	0	1

Autopsy Cases

f) No.		3	1	3	4	0	0	3	0	0	1	0	0	8	0	0	4	3	5
g) No. diagnosed correctly		0	1	0	2	0	0	2	0	0	1	0	0	7	0	0	2	1	3

Surgical Pathology Cases

h') No.		0	0	0	3	1	4	1	0	0	0	9	1	0	2	2	0	0	1
h) No. diagnosed correctly		0	0	0	3	1	2	1	0	0	0	5	0	0	1	2	0	0	1



c) Incorrect diagnoses

The percentage of cases categorized as Incorrect showed a marked rise from 1922 to 1942, and a subsequent smaller fall to 1962, for the total and for the Gastroenterological, Neurological and Miscellaneous categories. In the Cardiovascular-respiratory and Genitourinary cases the percentage Incorrect rose steadily with time. In all major categories the percentage Incorrect was higher in 1962 than in 1922.

In the Cardiovascular-respiratory category the percentage Incorrect was below that for the total cases in 1922 and 1942, reaching the level for the total only in 1962, while in the Gastroenterological category the percentage Incorrect was above the figure for the total in 1922 and 1942, and fell to that level in 1962.

None of the Dermatological cases was Incorrect, and in the other smaller categories only a small proportion of cases was diagnosed incorrectly.

d) Correct diagnoses

The pattern of cases categorized as Correct mirrored that of cases rated Incorrect in all the major categories as well as the total. In the Cardiovascular-respiratory, Genitourinary and Miscellaneous groups the percentage Correct fell steadily with time. In the Gastroenterological and Neurological categories the percentage Correct dropped in 1942 and rose by a smaller amount to 1962. The majority of cases in the smaller categories were diagnosed correctly, with the exception of Hematological-lymphatic cases, most of which were rated Partly Correct.



e) Partly Correct diagnoses

The percentage of Partly Correct cases increased each year for the total and in all the major categories except Cardiovascular-respiratory, in which the percentage remained stable. In each of the smaller categories except Hematologic-lymphatic, the proportion Partly Correct was consistently small. The overall increase in percentage of Partly Correct cases probably reflects the increasing complexity of cases presented, with more diagnoses and thus more potential for partial error.

f) Autopsy cases

The percentage of Autopsy cases decreased with time for the total and also in the Cardiovascular-respiratory, Gastroenterological, and Genitourinary groups. In the Neurological and Miscellaneous categories the proportion of Autopsy cases decreased from 1922 to 1942, and subsequently rose by a smaller amount to 1962. All of the Hematologic-lymphatic and all but one of the Multi-systemic cases were categorized as Autopsy. All the Metabolic cases in 1922 were Autopsy cases, but none in 1942 or 1962. A relatively high proportion of Orthopedic and Gynecological cases were Autopsy cases in 1922, but none in 1942 or 1962. Three of the four Dermatological cases in 1922 were categorized as Autopsy.

Thus the proportion of Surgical Pathology cases presented at the clinico-pathological conferences has been rising, and in 1942 and 1962 the proportion was particularly high (higher than for the total) in the Gastroenterological, Gynecological, Metabolic and Orthopedic categories.



g) Accuracy in Diagnosis of Surgical Pathology vs. Autopsy Cases

In 1922 all four cases diagnosed by Surgical Pathology were Correct whereas 71% of the Autopsy cases were Correct. In 1942 35% of Surgical Pathology and 48% of Autopsy cases were Correct, and in 1962 43% of Surgical Pathology and 40% of Autopsy cases were Correct. Thus whether the case was classified as Surgical Pathology or Autopsy did not seem to influence the overall accuracy of diagnosis.

The incidence of correct diagnosis of Autopsy cases decreased with time in all major categories except Gastroenterological, in which there was a high incidence of Correct diagnoses of Autopsy cases in 1922 and 1962, but a lower incidence in 1942. The percentage of Surgical Pathology cases diagnosed correctly rose from 1942 to 1962 for the total and for all major categories except Cardiovascular-respiratory, in which it fell.

In 1942 and 1962 in the Gastroenterological category, the percentage of Autopsy cases diagnosed correctly was higher than the percentage of Surgical Pathology cases diagnosed correctly, but in the Cardiovascular-respiratory category a higher proportion of Surgical Pathology cases was diagnosed correctly. Thus for the Gastroenterological group, in which there was a high proportion of Surgical Pathology cases, a higher proportion of Autopsy cases were diagnosed correctly. In the Cardiovascular-respiratory group in which there was a high proportion of Autopsy cases, a higher percentage of Surgical Pathology cases was diagnosed correctly.





2) Separate Analysis of Diagnostic Reasoning in Cardiovascular-respiratory Cases

A special analysis of diagnostic reasoning was performed for cases in the Cardiovascular-respiratory category.

Forty-one such cases were presented in 1922, and 28 in each of 1942 and 1962. (See Figure 3(p.20) and Table 5 (p.21)).

a) Evidence relied upon by discussor: Clinical vs. Para-clinical

The discussor's main diagnostic reliance was on Para-clinical data in 10% of cases in 1922, 39% of cases in 1942 and 43% in 1962. As the reliance on Para-clinical data increased, however, the percentage of correct diagnoses decreased, from 63% in 1922, to 43% in 1942 and 36% in 1962.

In both 1922 and 1962, the percentage of Clinical cases diagnosed correctly was considerably higher than the percentage of Para-clinical cases diagnosed correctly, but was slightly lower in 1942.

b) Types of Errors (Figure 4 (p. 22) and Table 6 (p. 23))

Errors of Inaccurate Focus were most frequent in 1922, 1962, and in the total of all three years. Errors of Omission were second most common in every year and the total. Errors of Inappropriate Exclusion were most frequent in 1942, but third most frequent in the other years and the total. Errors of Addition contributed the smallest percentage in each year.

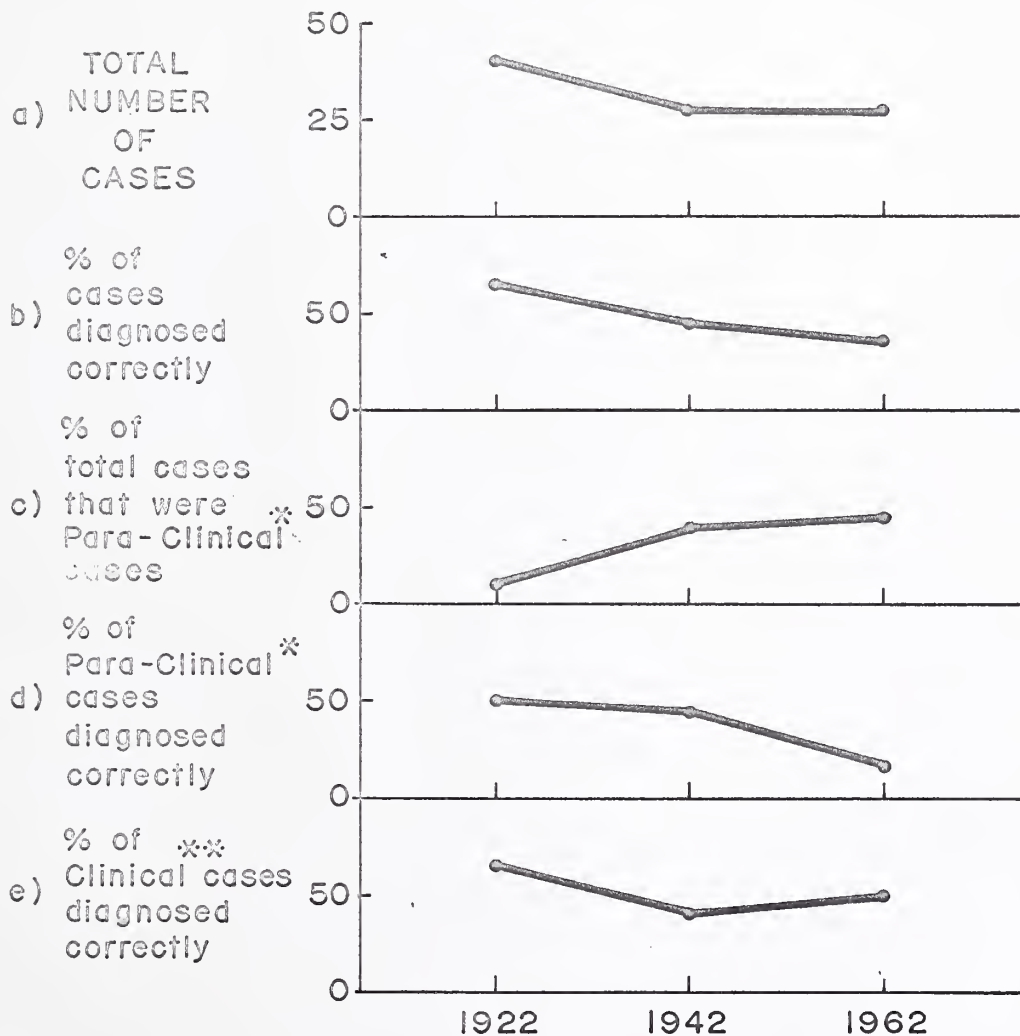
#### IV. DISCUSSION

1.) Comments on the Clinico-pathological Conferences

The character of the clinico-pathological conferences at the Massachusetts General Hospital has changed considerably from 1922 to 1962.



FIG. 3 CARDIOVASCULAR-RESPIRATORY CASES  
ACCURACY OF DIAGNOSIS AND MAJOR DIAGNOSTIC RELIANCE



\* Para-Clinical: Physician relied mainly on para-clinical evidence in reaching the diagnosis.

\*\* Clinical: Physician relied mainly on clinical evidence in reaching the diagnosis.



TABLE 5

Cardiovascular-respiratory  
Cases  
Accuracy of Diagnosis and Major Diagnostic Reliance

Year		<u>1922</u>	<u>1942</u>	<u>1962</u>
a) Total Number of Cases		41	28	28
b) Total cases diagnosed correctly	Number	26	12	10
	% of total	63	43	36
c) Cases with major diagnostic reliance on <u>Para-clinical</u> data	Number	4	11	12
	% of total	10	39	43
d) <u>Para-clinical</u> cases diagnosed correctly	Number	2	5	2
	% of <u>Para-clinical</u> cases	50	45	17
e) Cases with major diagnostic reliance on <u>Clinical</u> data	Number	37	17	16
	% of total	90	61	57
f) <u>Clinical</u> cases diagnosed correctly	Number	24	7	8
	% of <u>Clinical</u> cases	65	41	50



FIG. 4 TYPES OF ERRORS

- I OMISSION
- II INACCURATE FOCUS
- III INAPPROPRIATE EXCLUSION
- IV ADDITION

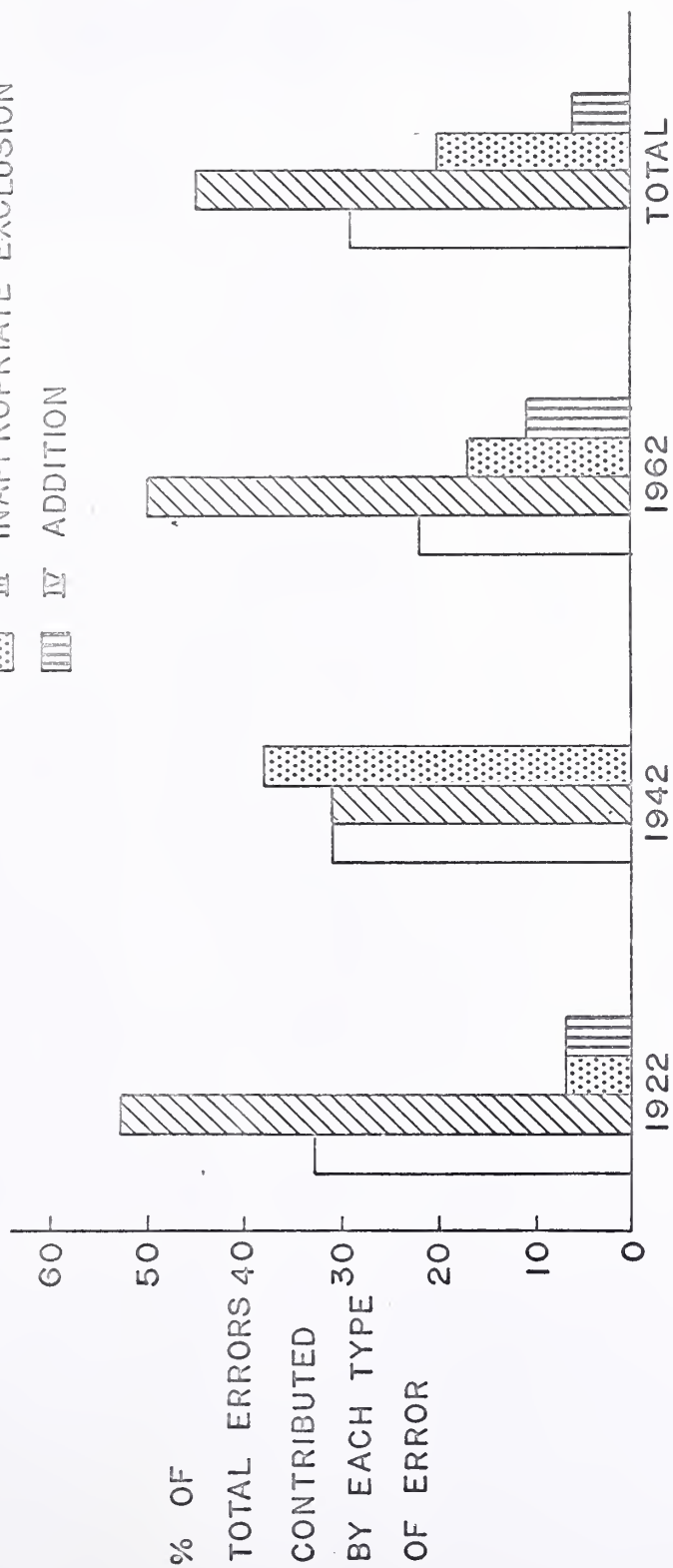






TABLE 6

TYPES OF ERROR  
Cardiovascular-respiratory  
cases

	Total errors	<u>Omission</u>	<u>Inaccurate</u>	Type of Error <u>Focus</u>	<u>Inappropriate</u> <u>Exclusion</u>	<u>Addition</u>
<u>1922</u>						
Number	15	5	8		1	1
% of total	100	33	53		7	7
<u>1942</u>						
Number	16	5	5		6	0
% of total	100	31	31		38	0
<u>1962</u>						
Number	18	4	9		3	2
% of total	100	22	50		17	11
<u>Total</u>						
Number	49	14	22		10	3
% of total	100	29	45		20	6



In 1922, three of the case records were presented for a discussion of management only, without autopsy findings. These were cases of hemorrhagic disease of the newborn, tabes dorsalis, and chronic lead poisoning. In another case, a neurological problem, the pathologist did not have the answer to the diagnostic problem, since he did not examine the brain. In another case the clinical findings were described and the discussion given before the chest x-ray was presented. When the x-ray was revealed, it allowed the diagnosis of bronchopneumonia to be made, and no pathological findings were given. The above five cases were not included in the analysis, as they did not compare clinical and morphological findings.

It appears that in 1922 the clinician, rather than the pathologist, selected the cases for discussion, which explains why on occasion the pathologist did not have the answer. The atmosphere was more often one of common concern over the cause of the patient's death; the discussion was generally a mutual interchange between clinician and pathologist, rather than one in which the pathologist gave the final answer. In one case,\* the clinician, after hearing the pathological findings, refused to accept them as an explanation for the clinical problem.

\*The patient had progressive neurological signs, fever, and a stiff neck. Cerebrospinal fluid findings were: "Fehling's solution not reduced; albumin 0.07%; white count 170 per cubic millimeter". The pathologist found a solitary tubercle of the right lobe of the cerebellum, but no meningitis. The clinician felt that "a solitary tubercle alone cannot account for such a spinal fluid", and he concluded that tuberculous meningitis must have complicated the localized tuberculosis despite the absence of gross findings at autopsy.<sup>16</sup>



This early atmosphere, in which the pathologist regarded the clinician as a scholarly collaborator, rather than as the object of a "test", may have existed because in 1922 the majority of cases were discussed by one of three physicians: Dr. Richard C. Cabot, Dr. Hugh Cabot, and Dr. Edward L. Young, Jr. Occasional contributions were made by other physicians, but most of the cases were discussed by one of the three men just cited. In 1942 and 1962, however, each case was discussed by a different person, with one physician rarely discussing more than a few cases in the year.

The format of the clinico-pathological conferences in 1922 was somewhat different from that of 1942 and 1962. In many cases in 1922, operative findings were revealed after part of the discussion. Then followed a description of the subsequent course of the patient, and further discussion by the clinician. In some cases the clinician was called upon to correlate the autopsy findings after they had been given.

The clinical material presented in 1922 was somewhat different from that of later years. On the average in 1922, the patients were younger, and many died of infectious diseases which now would usually respond to antibiotic therapy. Some cases in 1922 might be labelled "straightforward" today, such as those cases with "arteriosclerosis" as the major diagnosis and primary cause of death. Electrocardiography and radiology were rarely used, and laboratory tests consisted mainly of the white blood cell count, hemoglobin and blood sugar determinations, urinalysis, serologic studies such as Wasserman and Widal tests, and



bacteriologic cultures. Considerably more para-clinical data were given in 1942 and 1962 than in 1922, but more detailed reports of the history and physical examination were included in 1922.

## 2.) Interpretation of Results

One striking finding of this study was that, despite the aid of modern ancillary tests, contemporary clinicians were not as correct in the clinico-pathological conference diagnoses as were the doctors of more than forty years ago. One obvious possible explanation for this situation is the changing difficulty of the cases presented at clinico-pathological conferences, although the general distribution of types of cases presented did not alter during the forty year period. Nevertheless, the studies of the accuracy of clinical diagnoses in routine autopsy cases<sup>10,11</sup> found an overall higher percentage of clinical accuracy than the present study of clinico-pathological conferences. Thus the cases chosen for clinico-pathological conference presentation produce more diagnostic difficulties than the average autopsy case.

No consistent relationship was found between the accuracy of diagnosis and whether a case was classified as Autopsy or Surgical Pathology.

Another factor which may contribute to the lower modern accuracy at the clinico-pathological conference is the reliance on data obtained away from the bedside. In the Cardiovascular-respiratory category, as the discussor's reliance on para-clinical data increased, the percentage of correct diagnosis decreased. A considerably higher percentage of Clinical than Para-clinical





cases were diagnosed correctly.

In 1922, for example, when laboratory data were limited, clinical signs and symptoms were of major importance in formulating the diagnosis. By 1942 certain para-clinical facilities (such as x-ray and electrocardiograph) were more widely used and were often of great diagnostic value. By 1962, however, many new laboratory tests were available, but the significance and validity of these tests had not been fully evaluated, and thus reliance on new tests may have often led to errors.

In discussing a clinico-pathological conference in 1963, Dr. Richard Field analyzed the clinical record of that case and found that it contained "35 positive findings, of which 40% are derived from signs found on physical examination and 30% from the history. Of the 9 bits of negative information provided, 85% came from the laboratory determinations. From these figures one can conclude that in the practice of medicine the history and physical examination are still rewarding efforts, and that the laboratory examination can add considerable confusion to the picture."<sup>17</sup> In their previously described study, Gruver and Freis<sup>11</sup> noted that when the patients could not give a history, the incidence of errors in diagnosis was considerably higher.

Errors of omission remained surprisingly high in the clinico-pathological discussions each year, although the discussor had presumably had time to contemplate many diagnostic possibilities. Such errors of omission may occur even more readily under pressure of the ordinary practice of medicine, where less time is available and where each case may receive less concentrated thought.



The high proportion of these diagnostic errors of omission has important implications in the study of computer aids to diagnosis. A computer can store a great deal of information in its vast "memory", and has the capacity for rapid retrieval of the information. If properly programmed according to symptoms and signs, it can remind physicians of diagnostic possibilities which might otherwise be overlooked, and thus help to increase diagnostic accuracy in cases in which the error was one of omission.

Another common source of error in diagnosis was inappropriate exclusion. One type of computer program may be helpful in eliminating this type of error: a "flow-chart" model approximating the rule-in, rule-out, approach to diagnosis used by many physicians. Before flow-charts for diagnosis of given signs and symptoms can be successfully formulated, however, strict criteria for diagnosis must be established. A flow-chart may be a useful way of recording such criteria. Since errors of inappropriate exclusion must be based on inaccurate criteria, such errors would be drastically reduced by following such a model.

Some authors have constructed mathematical models for diagnosis using Bayes' theorem, a concept of inverse probability.<sup>1,3-6</sup> Problems with the use of Bayes' theorem in clinical medicine have been pointed out elsewhere.<sup>2,18,19</sup> In the example of an error of inappropriate exclusion described previously, the discussor ruled out tuberculosis on the basis of negative intradermal tests. For use with Bayes' theorem, the negative PPD would be independently assigned a certain weight in determining the probability of the patient's having tuberculosis. By use of a



flow-chart formulation, the systemic illness of the patient could first be taken into consideration, and the PPD result then given more or less importance depending on the rest of the clinical picture.

Errors of addition made up the smallest category of error. However, this type of error may become more frequent by a future computer's presentation of many possible diagnoses for consideration. Rather than eliminating the need for thought and decision on the part of the physician, the computer may indeed present him with more diagnostic considerations and problems.

Errors of inaccurate focus occurred in cases in which the physician discussed the possible diagnoses, but could not rule out one over the other. The essential lack was of pathognomonic evidence in favor of one or the other diagnosis, and thus would be difficult to improve by a computer program.

The outlook for the use of computers in medical diagnosis is promising. The reduction in errors of omission and errors of inappropriate exclusion would be well worth the price of a possible increase in errors of addition. From the point of view of the patient's welfare, errors of omission or of inappropriate exclusion may be considerably more serious than errors of addition or of inaccurate focus. Thus computers can be a significant aid to diagnosis for the physician, but will concomitantly present him with new intellectual challenges and difficulties.

#### V. SUMMARY AND CONCLUSIONS

1. No significant change was found in the general distribution of types of published cases that had been presented at the



clinico-pathological conferences of the Massachusetts General Hospital during the years 1922, 1942, and 1962. Cardiovascular-respiratory and gastroenterological cases occurred most frequently, followed by genitourinary and neurological cases. The absolute number of published cases became smaller each year.

2. Demonstrable etiological anatomical lesions were present in 96% to 99% of the cases, indicating that the clinico-pathological conference has remained an anatomical exercise and is biased in this way as a means of studying diagnosis of diseases in modern medicine.

3. The percentage of total cases diagnosed incorrectly in 1962 was considerably higher than in 1922, but slightly lower than in 1942.

4. The percentage of Autopsy cases was highest in 1922, considerably lower in 1942, and lowest in 1962. Whether the case was categorized as Autopsy or Surgical Pathology was not a consistent factor in determining the accuracy of diagnosis.

5. In the Cardiovascular-respiratory category, diagnostic reliance on para-clinical data increased each year. As the diagnostic reliance was diverted from clinical to para-clinical data, the percentage of correct diagnoses decreased.

6. The most frequent type of error was one of Inaccurate Focus, and Errors of Omission were second most common. Although Errors of Inappropriate Exclusion were most frequent in 1942, they were third most frequent in other years. Errors of Addition contributed the smallest percentage of errors in each year.

7. The use of computers in medical diagnosis may aid physicians in reducing errors of omission and of inappropriate





exclusion, but not of inaccurate focus. The computer may increase errors of addition by including many extraneous diagnostic possibilities. The reduction of errors of omission and errors of inappropriate exclusion would be well worth the price of the possible increase of errors of addition, however, since the former types of error may be considerably more serious for the patient. Thus computers may significantly aid the physician in diagnosis, but will by no means eliminate the need for thoughtful clinical judgment.



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