RETINAL DIALYSIS: A STATISTICAL AND GENETIC STUDY TO DETERMINE PATHOGENIC FACTORS

BY *William S. Hagler*, MD

INTRODUCTION

A DIALYSIS IS A SPECIFIC TYPE OF RETINAL TEAR THAT IS ORIENTED CIRCUMferentially and located adjacent to the ora serrata. It can be as short as 2° or 3° or as long as 180°. A dialysis is usually located either in the ciliary epithelium just anterior to the ora or in the retina at or slightly posterior to the ora, although rarely both the ciliary epithelium and retina are involved by this type of tear. We have classified dialyses as "anterior" when they are located in the ciliary epithelium and "posterior" when they are located in the retina posterior to the ora.

Although this type of tear was first described by Leber[1] in 1882, it was Anderson[2] who, in 1932, suggested use of the term "dialysis" instead of "disinsertion." Anderson,[2] Gonin,[3] and Shapland[4] were the first to describe and emphasize some of the major differences in the clinical characteristics of retinal detachment produced by a dialysis compared with retinal detachment produced by other types of tears.

A review of the literature reveals frequent confusion among observers in distinguishing between giant tears and retinal dialyses.[2,5-8] This confusion appears to arise because the ophthalmoscopic appearances of posterior dialyses and giant tears are sometimes similar. Dialyses can be large, even occasionally greater than 90°, and the posterior edge can be highly elevated and gape back toward the optic disc. Thus, they may resemble giant tears that have not completely rolled over (Fig 1, A & B). However, there are several noticeable differences. In a dialysis the posterior edge does not roll back on itself and become inverted nor is there ever a radial posterior extension at one end of a dialysis as frequently occurs in a giant tear (Fig 1, C). In giant tears, the posterior edge of the vitreous base is always attached to the narrow anterior fringe of the retina or ciliary epithelium, and in dialyses the vitreous base is attached to the posterior edge of the retina.[9] In addition, a posterior vitreous detachment is invariably present in giant tears[10] and seldom, if ever, present in dialyses. Thus, if a giant tear is large

Figure 1A

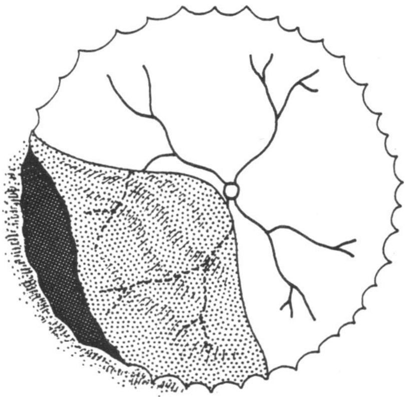


Figure 1B

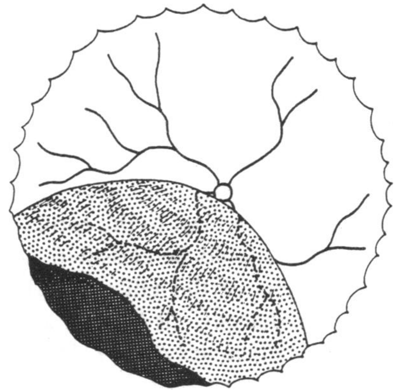


Figure 1C

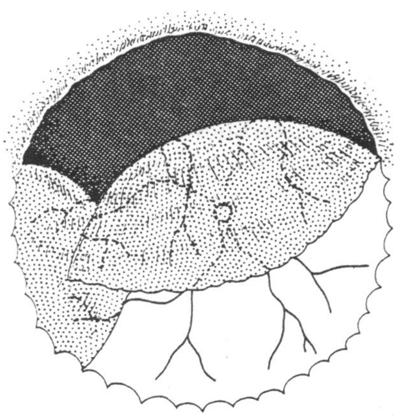


Figure 1D

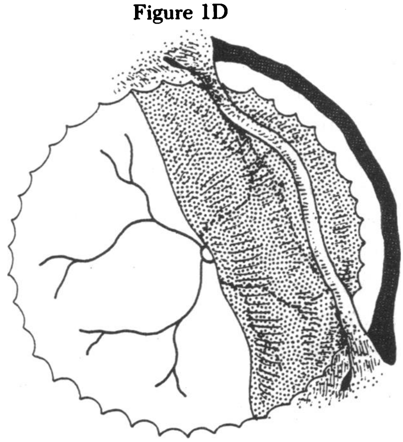


Figure 1E

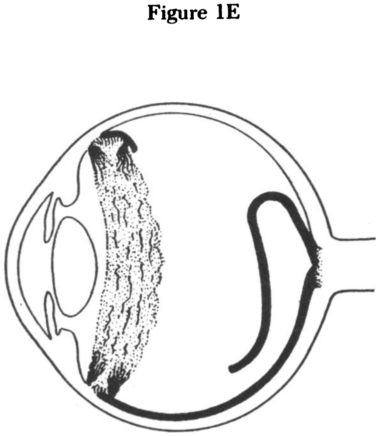
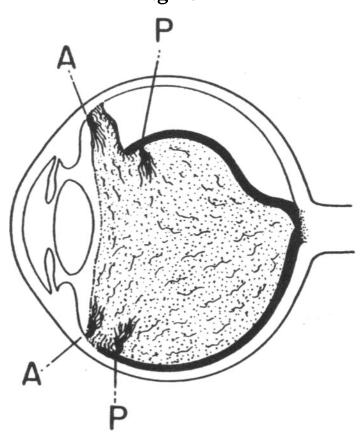


Figure 1F



enough, the retina is free to fold back upon itself and become inverted (Fig 1, C & E), whereas in a dialysis, the retina is prevented from becoming inverted by the vitreous base, which is attached to the posterior margin of the retinal tear, and by the absence of a posterior vitreous detachment (Fig 1, F). It is frequently impossible to clearly visualize the vitreous detachment ophthalmoscopically, and is therefore necessary to examine the vitreous attachment to the retina with a slit lamp to determine whether a given tear should be classified as a giant tear or as a dialysis.

A dialysis of the ciliary epithelium, which we have classified as an "anterior dialysis," is located anterior to the ora and involves the ciliary epithelium primarily (Fig 1, D). Our data will firmly establish that this form of dialysis occurs most often as a result of a severe contusion injury and that it is frequently associated with an avulsion of the base of the vitreous along with a strip of the ciliary epithelium. In addition to contusion injuries, ciliary epithelial dialyses may also result from contraction of vitreous membranes from any cause, such as those resulting from penetrating wounds, chorioretinitis, or certain proliferative retinal vascular disorders such as retrolental fibroplasia. The clinical characteristics and the method of production following contusion injuries of this special type of dialysis have been well described by Cox et al,[11] Weidenthal and Schepens,[12] and Ryan and Allen.[13]

This prospective study was begun 18 years ago to try to determine the pathogenesis of this type of retinal tear. Previous investigators compiled and summarized data and reported anecdotal cases. There are no published reports on dialyses employing modern statistical testing methods to determine significance. Many reports are contradictory. For example, some indicate dialyses are frequently bilateral, ranging from 30% to 54%,[14-17] whereas others indicate a low occurrence of bilaterality, varying from 2% to 8%.[18-21] There are numerous reports regarding the role of trauma in the production of dialyses but little agreement among investigators as to its

FIGURE 1

A: Small giant tear and B: large retinal dialysis with similar ophthalmoscopic appearance. In absence of rolled-over retina, the only ophthalmoscopic distinction may be presence of detachment of ciliary epithelium in giant tear (A). C: Large giant tear. Retina typically rolls over, especially with posterior extension at one extremity. Frequently ciliary epithelium is highly elevated. D: Dialysis of ciliary epithelium. Avulsed strip of ciliary epithelium may be intact (above) or occasionally torn. Note associated detachment of ciliary epithelium. Actual tear in ciliary epithelium is usually subtle and difficult to visualize. E: Giant tear. Vitreous base is always attached to anterior portion of retina and ciliary epithelium. Posterior vitreous detachment is characteristic, permitting retina to roll over. F: Dialysis showing posterior (P) attachment of vitreous base located posteriorly. Absence of vitreous detachment and bridging of dialysis by intact hyaloid prevent retina from rolling over.

importance.[2,17-20,22-24] The fact that a wide variety of etiologic theories have been proposed in an attempt to find a single mechanism for production would tend to indicate that there may be multiple mechanisms. From a review of the literature, it is clear that there is no general agreement among investigators as to what percentage, if any, of the nontraumatic dialyses is inherited.[14,15,17,25-29]

This report will summarize the results of the detailed statistical analysis of a large group of patients with retinal detachment produced by a dialysis. These data should help eliminate some of the confusion and hopefully will increase our knowledge regarding a variety of possible pathogenic factors.

MATERIALS AND METHODS

All patients who underwent surgical treatment for a retinal detachment between 1960 and 1978 are included in this study. A standard ophthalmic and general medical history was recorded on each patient. In patients with a dialysis, special emphasis was placed on obtaining an accurate family history regarding retinal detachment, glaucoma, myopia, cataract, or blindness from any cause. Additional questions were asked regarding prematurity, cleft palate, mental deficiency, and skeletal abnormalities. A complete ophthalmologic evaluation was performed on both eyes of every patient. In addition, a detailed fundus drawing was prepared using the stereoscopic indirect ophthalmoscope to record the shape, size, location, and characteristics of all tears as well as areas of chorioretinal degeneration, peripheral microcystoid degeneration, and areas of white with and without pressure. In most instances biomicroscopic examination of the anterior and posterior segment using a three-mirror Goldmann lens was performed to inspect the chamber angle and the basic structure and attachments of the vitreous body.

At the time of the patient's discharge from the hospital, the information obtained regarding history, ocular findings, type of surgery performed, and operative complications was recorded on a specially designed, detailed checklist containing approximately 500 bits of information (Fig 2). The late complications and the final anatomic and visual results were entered at a minimum of three months postoperatively on the same checklist. This information was then key punched and stored on computer tape for subsequent retrieval. This method of data storage and retrieval was modified from one initially developed by Norton[30] and subsequently described by Hagler et al.[31]

To supplement the single question in our records regarding the presence or absence of a family history of retinal detachment, we devised and

Figure 2A

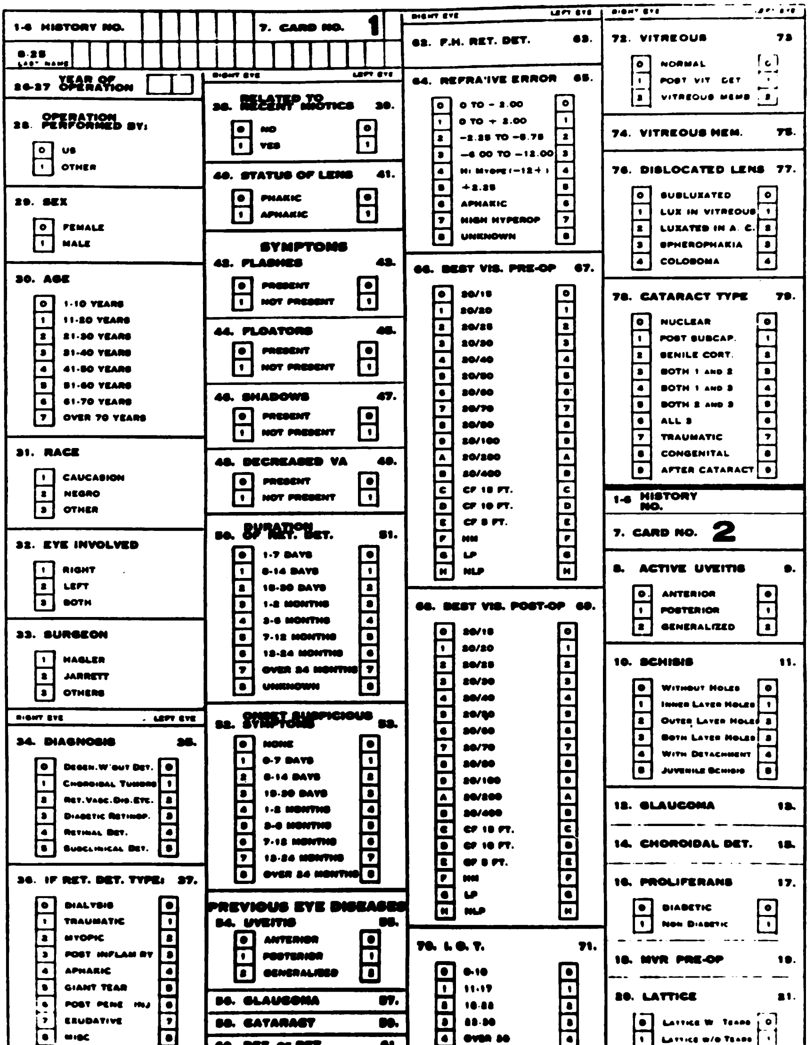

1-6 HISTORY NO.
7. CARD NO. 1
8-25 LAST NAME
26-27 YEAR OF OPERATION
28. OPERATION PERFORMED BY: 0 US; 1 OTHER
29. SEX: 0 FEMALE; 1 MALE
30. AGE: 0 1-10 YEARS; 1 11-20 YEARS; 2 21-30 YEARS; 3 31-40 YEARS; 4 41-50 YEARS; 5 51-60 YEARS; 6 61-70 YEARS; 7 OVER 70 YEARS
31. RACE: 1 CAUCASION; 2 NEGRO; 3 OTHER
32. EYE INVOLVED: 1 RIGHT; 2 LEFT; 3 BOTH
33. SURGEON: 1 HAGLER; 2 JARRETT; 3 OTHERS
RIGHT EYE / LEFT EYE
34. DIAGNOSIS 35.: 0 DEGEN. W'OUT DET.; 1 CHOROIDAL TUMORS; 2 RET. VASC. DIS. ETC.; 3 DIABETIC RETINOP.; 4 RETINAL DET.; 5 SUBCLINICAL DET.
36. IF RET. DET. TYPE: 37.: 0 DIALYSIS; 1 TRAUMATIC; 2 MYOPIC; 3 POST INFLAM RD; 4 APHAKIC; 5 GIANT TEAR; 6 POST PENE INJ; 7 EXUDATIVE; 8 MISC
RIGHT EYE / LEFT EYE
38. RELATED TO RECENT MIOTICS 39.: 0 NO; 1 YES
40. STATUS OF LENS 41.: 0 PHAKIC; 1 APHAKIC
SYMPTOMS
42. FLASHES 43.: 0 PRESENT; 1 NOT PRESENT
44. FLOATORS 45.: 0 PRESENT; 1 NOT PRESENT
46. SHADOWS 47.: 0 PRESENT; 1 NOT PRESENT
48. DECREASED VA 49.: 0 PRESENT; 1 NOT PRESENT
50. DURATION OF RET. DET. 51.: 0 1-7 DAYS; 1 8-14 DAYS; 2 15-30 DAYS; 3 1-2 MONTHS; 4 3-6 MONTHS; 5 7-12 MONTHS; 6 13-24 MONTHS; 7 OVER 24 MONTHS; 8 UNKNOWN
52. ONSET SUSPICIOUS SYMPTOMS 53.: 0 NONE; 1 0-7 DAYS; 2 8-14 DAYS; 3 15-30 DAYS; 4 1-2 MONTHS; 5 3-6 MONTHS; 6 7-12 MONTHS; 7 13-24 MONTHS; 8 OVER 24 MONTHS
PREVIOUS EYE DISEASES
54. UVEITIS 55.: 0 ANTERIOR; 1 POSTERIOR; 2 GENERALIZED
56. GLAUCOMA 57.
58. CATARACT 59.
60. DET. OF RET. 61.
RIGHT EYE / LEFT EYE
62. F.H. RET. DET. 63.
64. REFRACTIVE ERROR 65.: 0 0 TO -2.00; 1 0 TO +2.00; 2 -2.25 TO -5.75; 3 -6.00 TO -12.00; 4 HI MYOPE (-12+); 5 +2.25; 6 APHAKIC; 7 HIGH HYPEROP; 8 UNKNOWN
66. BEST VIS. PRE-OP 67.: 0 20/15; 1 20/20; 2 20/25; 3 20/30; 4 20/40; 5 20/50; 6 20/60; 7 20/70; 8 20/80; 9 20/100; A 20/200; B 20/400; C CF 15 FT.; D CF 10 FT.; E CF 5 FT.; F HM; G LP; H NLP
68. BEST VIS. POST-OP 69.: 0 20/15; 1 20/20; 2 20/25; 3 20/30; 4 20/40; 5 20/50; 6 20/60; 7 20/70; 8 20/80; 9 20/100; A 20/200; B 20/400; C CF 15 FT.; D CF 10 FT.; E CF 5 FT.; F HM; G LP; H NLP
70. I.O.T. 71.: 0 0-10; 1 11-17; 2 18-22; 3 23-30; 4 OVER 30
RIGHT EYE / LEFT EYE
72. VITREOUS 73: 0 NORMAL; 1 POST VIT DET; 2 VITREOUS MEMB
74. VITREOUS MEM. 75.
76. DISLOCATED LENS 77.: 0 SUBLUXATED; 1 LUX IN VITREOUS; 2 LUXATED IN A. C.; 3 SPHEROPHAKIA; 4 COLOBOMA
78. CATARACT TYPE 79.: 0 NUCLEAR; 1 POST SUBCAP.; 2 SENILE CORT.; 3 BOTH 1 AND 2; 4 BOTH 1 AND 3; 5 BOTH 2 AND 3; 6 ALL 3; 7 TRAUMATIC; 8 CONGENITAL; 9 AFTER CATARACT
1-6 HISTORY NO.
7. CARD NO. 2
8. ACTIVE UVEITIS 9.: 0 ANTERIOR; 1 POSTERIOR; 2 GENERALIZED
10. SCHISIS 11.: 0 WITHOUT HOLES; 1 INNER LAYER HOLES; 2 OUTER LAYER HOLES; 3 BOTH LAYER HOLES; 4 WITH DETACHMENT; 5 JUVENILE SCHISIS
12. GLAUCOMA 13.
14. CHOROIDAL DET. 15.
16. PROLIFERANS 17.: 0 DIABETIC; 1 NON DIABETIC
18. MVR PRE-OP 19.
20. LATTICE 21.: 0 LATTICE W TEARS; 1 LATTICE W/O TEARS

FIGURE 2
Checklist used for recording of data by surgeon for all retinal detachment patients operated on in this series.

distributed a detailed questionnaire to the 224 patients with dialysis operated on during the past seven years; 98 questionnaires were returned. Seventy members of nine families returned for detailed ophthalmologic

Figure 2B

RIGHT EYE — LEFT EYE

22. MYOPIC DEGEN. 23.
24. SNAIL TRACK 25.
26. COBBLESTONE 27.
28. RADIAL DEGEN. 29.
30. DET. INOPER 31.
32. PARS PLANA CYSTS 33.
34. R. L. F. 35.
36. OTHER 37.

38. NO. OF RET. CYSTS 39.
- 0 NONE 0
- 1 1 1
- 2 2 2
- 3 3 3
- 4 4 OR MORE 4

40. IF APHAKIC 41.
- 0 ICCE 0
- 1 ECCE 1
- 2 LIN EXT/ASP 2

42. VITREOUS LOSS 43.
- 0 VIT. LOSS KNOWN 0
- 1 VIT. LOSS PROB. 1

44. STATUS PUPIL-APH. 45.
- 0 IRID.COMP..ADQ. 0
- 1 IRID.COMP.INADQ. 1
- 2 ROUND PUPIL ADQ. 2
- 3 ROUND P. INADQ. 3

46. VIT. IN WOUND 47.

48. NO. BREAKS 49.
- 0 NONE 0
- 1 1 1
- 2 2 2
- 3 3 3
- 4 4 4
- 5 5-10 5
- 6 10 + 6

TYPE BREAKS:
50. HOLE w/o OPERC. 51.
52. HOLE w OPERC. 53.
54. HORSESHOE 55.
56. GIANT TEAR 57.
- 0 IDIOPATHIC 0
- 1 POSTERIOR TO LAT 1
- 2 TRAUMATIC 2
- 3 POST. EDGE DIA. 3
- 4 POST. EDGE CRYO 4

58. MACULAR HOLE 59.
60. LINEAR RENT 61.
62. AVULSED RET. VES. 63.
64. TRAUMATIC HOLE 65.

RIGHT EYE — LEFT EYE

66. DIALYSIS 67.
- 0 DIA 1 QUAD 0
- 1 DIA 2 QUADS 1
- 2 DIA + 2 QUADS 2

68. LOC. ORAL DIA. 69.
- 0 LT 0
- 1 UN 1
- 2 UT 2
- 3 LN 3

70. LOC. ANT. DIALYSIS 71.
- 0 LT 0
- 1 UN 1
- 2 UT 2
- 3 LN 3

72. LOC. MOST POST BK. 73.
- 0 ORAL 0
- 1 EQUATORIAL 1
- 2 POST EQUATOR 2
- 3 MACULA 3

74. FIXED RET. FOLDS 75.
76. EQUATORIAL FLDS. 77.
78. MERIDIONAL FLDS. 79.

1-6 HISTORY NO.

7. CARD NO. **3**

8. STAR FOLDS 9.
10. ROLLED EDGES 11.

12. LOC. RET. BREAKS 13.
- 0 UT 0
- 1 LT 1
- 2 UN 2
- 3 LN 3
- 4 UT & LT 4
- 5 UT & UN 5
- 6 UT & LN 6
- 7 LT & UN 7
- 8 LT & LN 8
- 9 UN & LN 9
- A 3 QUADRANTS A
- B 4 QUADRANTS B

14. SHIFTING FLUID 15.

16. DEMARCATION LINES 17.
- 0 NONE 0
- 1 1 1
- 2 2 2
- 3 3 3
- 4 4 & 5 4
- 5 OVER 5 5

RIGHT EYE — LEFT EYE

WHICH QUAD. DET.
18. UT 19.
20. LT 21.
22. UN 23.
24. LN 25.
26. SUBCLINICAL 27.

28. MACULA STATUS 29.
- 0 ON 0
- 1 OFF 1
- 2 ON WITH PUCKER 2
- 3 OFF WITH PUCKER 3

30. HEIGHT MAC. DET. 31.
- 0 MINIMAL 0
- 1 MODERATE 1
- 2 BULLOUS 2

32. MAC. DEGEN. 33.
34. MAC. HEM. 35.
36. MAC. HOLE or CYST 37.

38. CILIARY EPITHELIUM 39.
- 0 ATTACHED 0
- 1 DET. < 1 QUAD 1
- 2 DET. > 1 QUAD 2
- 3 AVULSED 3

40. TRAUMA HISTORY 41.
- 0 VAGUE HX 0
- 1 DEFINITE HX 1
- 2 VERIFIED HX 2
- 3 INDIRECT TRAUMA 3

TRAUMA SIGNS
42. CORN.- SCL. LAC. 43.
44. KNOWN VIT. LOSS 45.
46. I. O. F. B. 47.
- 0 HISTORY 0
- 1 ACTUAL 1

48. HYPHEMA 49.
50. REC.CHAMBER ANG. 51.
52. DISLOCATED LENS 53.
54. TRAUMATIC CAT. 55.
56. COMMOTIO RET. 57.
58. RUP. IRIS. SPH. 59.
60. IRIDODIALYSIS 61.
62. OTHER 63.

RIGHT EYE — LEFT EYE

64. PREVIOUS RETINAL SURGERY ELSEWHERE 65.
- 0 SUCCESSFUL 0
- 1 FAILURE 1

66. PREVIOUS RETINAL SURGERY HERE 67.
- 0 SUCCESSFUL 0
- 1 FAILURE 1

68. NO. PREV. RET. OPS. BY US. 69.
- 0 NONE 0
- 1 ONE 1
- 2 TWO 2
- 3 THREE 3
- 4 FOUR OR MORE 4

70. NO. PREV. RET. OPS. BY OTHERS 71.
- 0 NONE 0
- 1 ONE 1
- 2 TWO 2
- 3 THREE 3
- 4 FOUR OR MORE 4

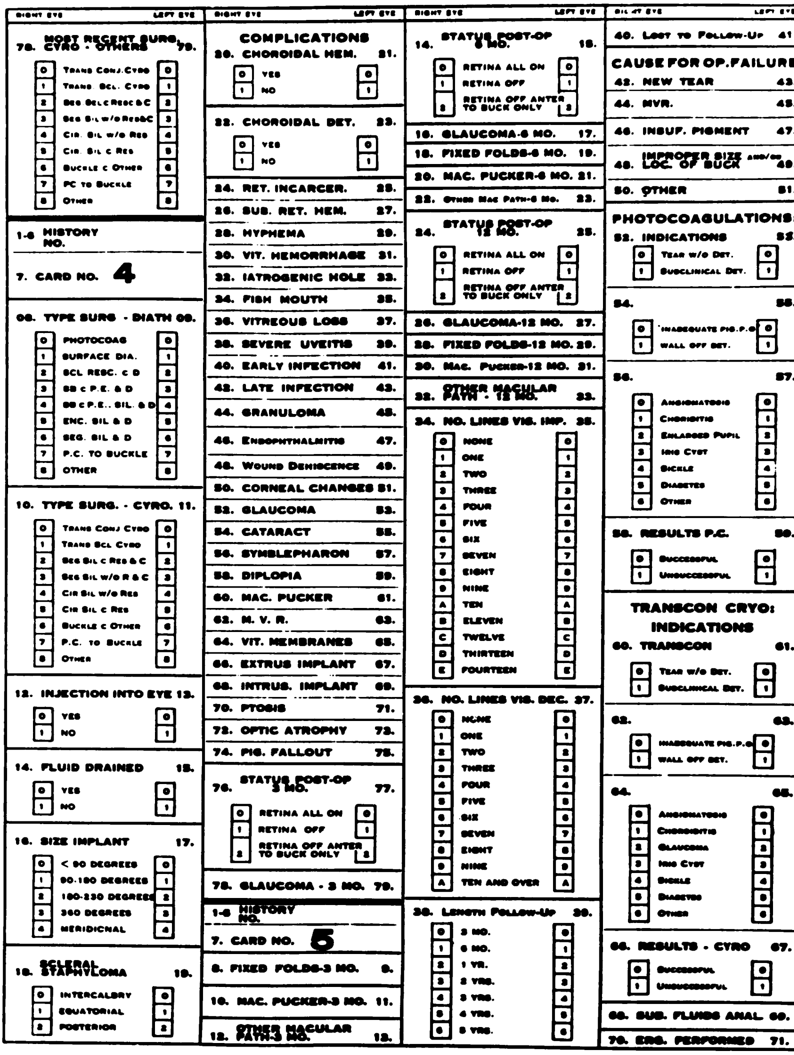
72. MOST RECENT SURG. DIA. - US. 73.
- 0 PHOTOCOAG 0
- 1 SURFACE DIA. 1
- 2 SCL RES EC & D 2
- 3 SB & PE. & D 3
- 4 SB & PE. SIL. & D 4
- 5 ENC. SIL & D 5
- 6 SEG SIL & D 6
- 7 P.C. TO BUCKLE 7
- 8 OTHER 8

74. MOST RECENT SURG. DIA. - OTHERS 75.
- 0 PHOTOCOAG 0
- 1 SURFACE DIA. 1
- 2 SCL RES EC & D 2
- 3 SB & PE. & D 3
- 4 SB & PE. SIL. & D 4
- 5 ENC. SIL & D 5
- 6 SEG SIL & D 6
- 7 P.C. TO BUCKLE 7
- 8 OTHER 8

76. MOST RECENT SURG. CYRO - US 77.
- 0 TRANS.CONJ.CYRO 0
- 1 TRANS. SCL CYRO 1
- 2 SEG.SCL.C.RES.C.C 2
- 3 SEG.SIL w/o RES.C 3
- 4 CIR. SIL w/o RES 4
- 5 CIR. SIL c RES 5
- 6 BUCKLE c OTHER 6
- 7 PC TO BUCKLE 7
- 8 OTHER 8

evaluation, and these family members were also examined by an independent geneticist, who recorded another complete ocular and systemic history and constructed a detailed pedigree. The geneticist performed a thorough physical examination to determine whether any dysmorphic features suggestive of any of the known genetic syndromes were present. In addition, biochemical screens were performed on the urine and serum

Figure 2C



for any of the abnormal metabolites associated with known genetic syndromes. Chromosomal analyses were performed on the two families who had additional family members with dialyses by culturing peripheral blood leukocytes and analyzing the chromosomes by Giemsa and standard techniques. Ten metaphase stages were scanned, and karyotypes were completed on two of these.

To determine more clearly the role of trauma in the production of a dialysis, a separate portion of the questionnaire was devised regarding previous ocular trauma. The results noted from this portion of the questionnaire were used to supplement and confirm the somewhat limited information available from our computer data bank recorded at the time of the patient's initial visit.

Available for analysis in this report was the information on 5,360 eyes of 4,880 consecutive patients who had had retinal detachment surgery between 1960 and 1978 performed by me or my associate. Only those eyes on which follow-up information had been recorded at three months or greater were included. Hundreds of pieces of information in various categories from each patient were tabulated, and the chi-square test for statistical significance was performed by a professional statistician wherever this was appropriate. A finding was considered significant only if the probability of it occurring by chance was equal to or less than 0.5% ($P \leq .005$). For the sake of readability, most results are expressed in percentage, rounded off to the nearest tenth. Unknown factors varied in the different categories and they were usually eliminated from the calculations. Occasionally, when inadequate information was available from our computer tape, a manual review of an adequate sample of charts was performed.

Dialyses can be classified into various etiologic and anatomic groups, but we elected to divide them into only two major groups, traumatic and nontraumatic, to compare each of these groups to each other as well as to the large group of retinal detachments produced by the other types of retinal tears. The main reasons for using the two groups, traumatic and nontraumatic, were because a high incidence of patients had signs or history of previous trauma and because numerous reports have implicated trauma in the pathogenesis of this disorder. Included in the nontraumatic group were those rare cases in which the dialysis appeared to result from vitreous loss following intraocular surgical treatment, contraction of vitreous membranes from chorioretinal inflammatory disease, or from proliferative retinal vascular disease.

RESULTS

During the 18-year period of this study, 4,811 patients had surgical treatment for detachment of the retina. Of these patients, 4,262 had only one eye treated and 549 had both eyes treated. The series, therefore, is composed of 5,360 eyes in 4,811 patients.

A dialysis was recorded as being present in 523 (9.8%) of the 5,360 eyes operated on (Table I). In some rare instances, one or more additional tear

TABLE I: COMPOSITION OF SERIES	
Total patients with surgical treatment	4,811
Total eyes with surgical treatment	5,360
Without Dialysis	4,837 (90.2%)
With Dialysis	523 (9.8%)

was present, such as a round hole or a horseshoe tear, but if one or more dialyses were present, for the purpose of this study, the eye was included in the dialysis group and the retinal detachment was considered to be caused by the retinal dialysis. In 4,837 eyes (90.2%), the retinal detachment was not caused by a dialysis; this group comprises the nondialysis group. In this group of eyes there was a variety of causes of the retinal detachment. Forty-four percent were classified as aphakic, 33% were myopic, and 2% were postinflammatory. Retinoschisis accounted for 4%, macular holes 1.4% and giant tears 2.5%. In 4% there was evidence of traction produced by a variety of systemic diseases, and 9% were classified as miscellaneous.

EVIDENCE OF TRAUMA

Eyes were placed in the traumatic dialysis group if they had one or more signs of serious ocular trauma, or if they had a definite and verified history of such trauma directly to the globe. The ocular signs of trauma used for this determination were evidence of a corneoscleral laceration, hyphema, presence of an intraocular foreign body, iridodialysis, recession of the anterior chamber angle, dislocation of the crystalline lens, rupture of the iris sphincter, traumatic cataract, commotio retinae, and avulsion of the ciliary epithelium.

Of the 523 eyes with dialysis, 156 (29.8%) had one or more of these trauma signs, as compared with 195 eyes (4.0%) of the nondialysis group

TABLE II: SIGNS OF TRAUMA

Signs	No. of Eyes Exhibiting Each Sign	
	Dialysis Group (523)	Nondialysis Group (4,837)
Corneoscleral laceration	48	70
Intraocular foreign body	17	61
Hyphema	24	18
Iridodialysis	7	12
Recession chamber angle	27	12
Dislocation of lens	25	24
Rupture of iris	6	5
Traumatic cataract	38	71
Commotio retinae	18	19
Avulsion ciliary epithelium	71	9

TABLE III: INCIDENCE OF TRAUMA

Evidence of Trauma	No.	(%)
Eyes with dialysis	(523)	
Verified history with trauma signs	146	
Verified history without trauma signs	45	
Traumatic dialysis group	191	(36.5)
Nontraumatic dialysis group	332	(63.5)
Eyes without dialysis	(4,837)	
Verified history with trauma signs	191	
Verified history without trauma signs	56	
Nondialysis trauma group	247	(5.1)
Nondialysis nontrauma group	4,590	(94.9)

(Table II). In addition, we elected to include in the traumatic dialysis group 45 eyes of patients who had a verified history of a previous severe ocular contusion, intraocular foreign body, or perforation of the cornea or sclera but who did not have a visible sign of the previous trauma recorded. We specifically excluded from the traumatic group 41 eyes of patients who gave a history of either mild trauma to the eye or indirect trauma to the head or neck, and these 41 eyes were included in the nontraumatic dialysis group. Therefore, 191 eyes, or 36.5% of the eyes with dialyses, were placed in the traumatic group, and 332 eyes (63.5%) in the nontraumatic group. Using the same criteria, trauma signs or history were present in only 5.1% of eyes in the nondialysis group; since this was such a small percentage of the total group, they were not analyzed separately, and the subsequent statistical studies were performed on all nondialysis eyes both traumatic and nontraumatic groups (Table III).

LOCATION OF DIALYSIS

The dialysis was located in the ciliary epithelium anterior to the ora in 171 eyes (33%) and posterior to the ora in 352 eyes (67%). The occurrence of a posterior extension of an anterior dialyses across the ora to involve the retina was so rare that its frequency was not tabulated. Of the 171 eyes in which the dialysis was located anterior to the ora, 106 (62%) had a visible avulsion of the vitreous base and 71 of these were associated with a visible avulsion of a strip of ciliary epithelium. Ninety-one percent of the 106 eyes with this finding had either a history or another sign of an ocular contusion or penetration.

TABLE IV: LOCATION OF DIALYSIS

Location	No. Eyes	Incidence	
Anterior to ora			
Nontraumatic	30	18%	
Traumatic	141	82%	
Total	171	100%	33%
Posterior to ora			
Nontraumatic	302	86%	
Traumatic	50	14%	67%
Total	352	100%	100%

Of the 171 eyes with a dialysis located anteriorly in the ciliary epithelium, 141 (82%) were traumatic and 30 (18%) nontraumatic in origin. On the other hand, only 50 (14%) of the 352 posterior dialyses were believed to be traumatic and 302 (86%) were nontraumatic. These same data can be expressed another way by stating that 74% of all traumatic dialyses are located anterior to the ora and 26% are posterior to the ora. Only 9% of nontraumatic dialyses are located anterior to the ora; 91% are located posteriorly. Table IV summarizes the location of the dialysis in respect to the ora.

The quadrant location of the largest dialysis was recorded for each eye in the traumatic group and the nontraumatic group (Fig 3). Sixty-six percent of the nontraumatic dialyses were located in the lower temporal quadrant; in the traumatic group, however, there was a high incidence in both the lower temporal and upper nasal quadrants, 30% and 46%, respectively. We can state, then, that the majority of the nontraumatic dialyses are located in the lower temporal quadrant, whereas the eyes with a traumatic dialysis, the incidence is high in both the lower temporal and the upper nasal quadrants. It was determined that 66% of all eyes with a dialysis located in the upper nasal quadrant had either a definite history or an objective sign of previous ocular trauma. In only 22% of eyes with a dialysis located in the lower temporal quadrant was there evidence of trauma.

AGE

The decade of the patient's age at the time of diagnosis was tabulated for each of the three major groups (Fig 4). The mode in the nondialysis group was in the sixth decade and in both of the dialysis groups in the second decade. The average age of patients without a dialysis was 66; with nontraumatic dialysis, 29; and with traumatic dialysis, 24.

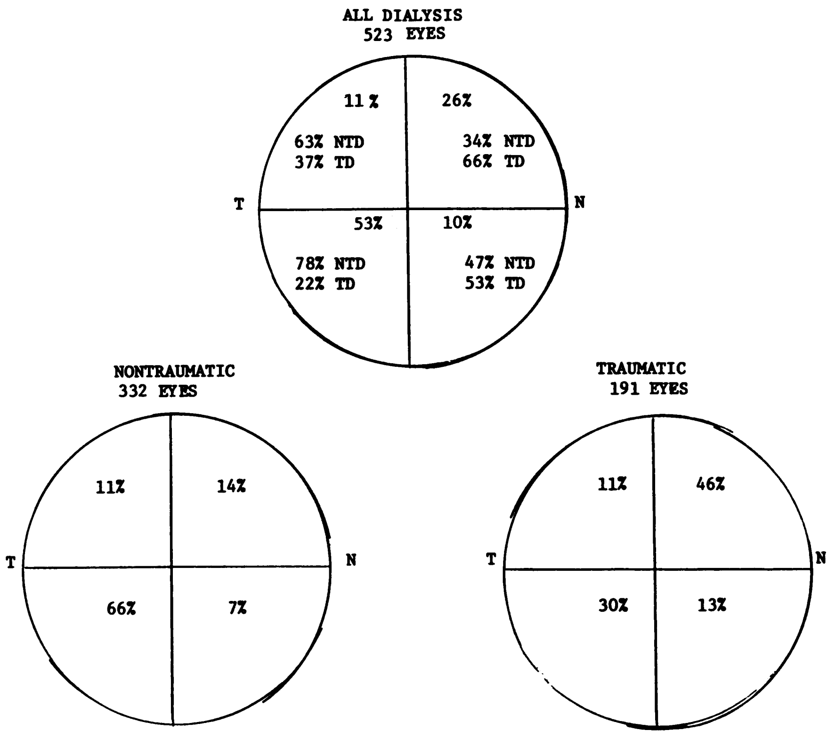


FIGURE 3
Quadrant location of dialyses: TD = traumatic dialysis, NTD = nontraumatic dialysis, T = temporal, N = nasal.

SEX AND RACE

In the nondialysis group, the ratio of men to women was 56% to 44%. In the dialysis group the ratio of men to women was 82% to 17%, and this higher incidence of men is statistically significant. Our total population of surgically treated patients was composed of 96.2% white patients and 3.8% nonwhite (mostly black) patients. The high incidence of nonwhite patients in both dialysis groups was statistically significant. However, the slightly higher incidence of 12% in the traumatic dialysis group compared with 7% in the nontraumatic dialysis group was not found to be significant. The composition of our groups according to race and sex is shown in Table V.

SYMPTOMS

The major symptoms given by the patients were tabulated (Table VI). The incidence of one or more symptoms was significantly lower in both dialysis

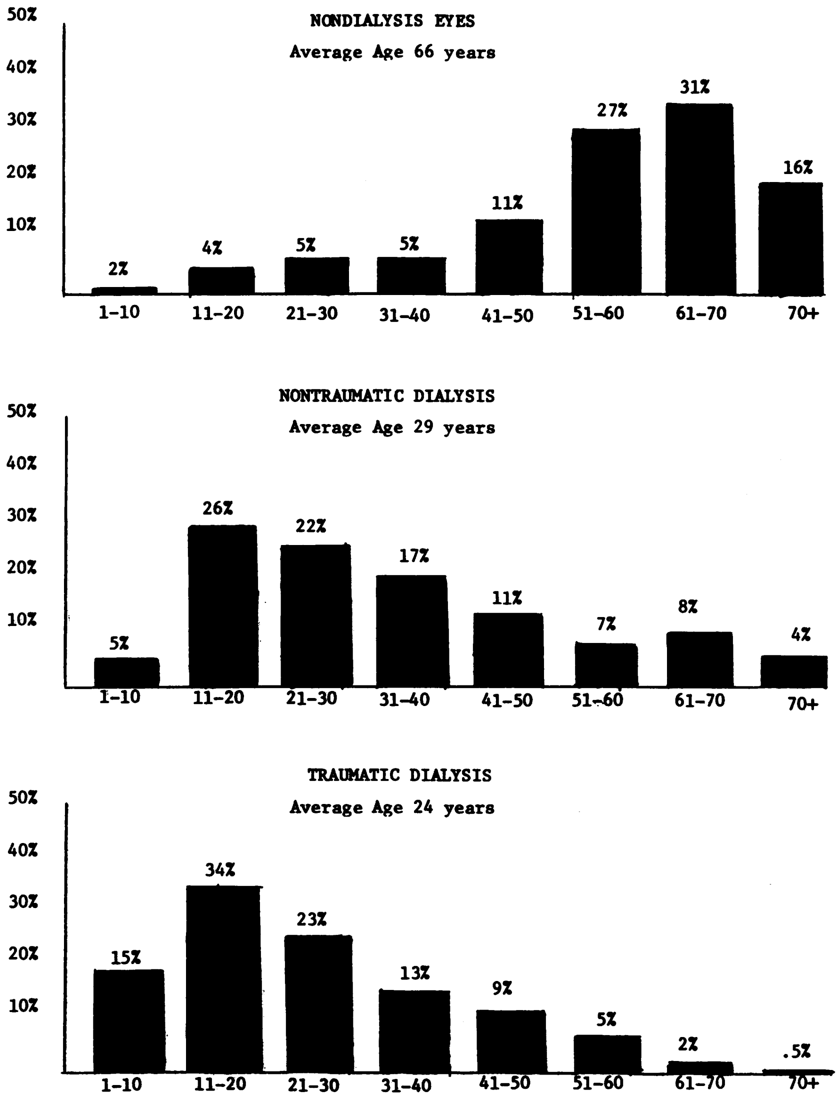


FIGURE 4
Patient ages at time of diagnosis for nondialysis group (top), nontraumatic dialysis group (center), and traumatic dialysis group (bottom).

TABLE V: RACIAL AND SEXUAL INCIDENCE

Type of Detachment	No. (%)			
	Male	Female	White	Nonwhite
Dialysis	358 (69)	162 (31)	480 (91)	46 (9)
Traumatic	166 (84)	32 (16)	174 (88)	23 (12)
Nontraumatic	192 (60)	130 (40)	296 (93)	23 (7)
Nondialysis	2,739 (56)	2,087 (44)	4,450 (96)	173 (4)

groups than in the nondialysis group, but there was not any statistically significant difference between the two dialysis groups. No symptoms were recorded in 61% of the patients in the nontraumatic dialysis group, 58% of the traumatic group, and 22% of the nondialysis group.

REFRACTIVE ERROR

A refraction was performed only occasionally, and usually the spherical equivalent was recorded from the patient's spectacle correction or from a rough retinoscopic examination. The results were available in 3,080 eyes (Table VII). Myopia was present in 26% of the nondialysis group, 18% of the nontraumatic dialysis group, and 16% of the traumatic dialysis group. Hyperopia was present in 48% of the nontraumatic dialysis group, 48% of the traumatic dialysis group, and only 12% of the nondialysis group. Emmetropia (0.00 to +0.50) was recorded in 18% of the nondialysis patients, compared with 33% of the nontraumatic dialyses and 32% of the traumatic dialyses patients. Aphakia occurred in 1% of the nontraumatic dialysis group, 4% of the traumatic dialysis group, and 44% of the nondialysis group. In summary, eyes with dialyses, traumatic or nontraumatic, were statistically more likely to be hyperopic or emmetropic and less likely to be aphakic or myopic than eyes without dialysis.

TABLE VI: INCIDENCE OF SYMPTOMS

Symptoms	% of Patients		
	Nontraumatic Dialysis	Traumatic Dialysis	Nondialysis
Flashes	12	16	72
Floaters	8	12	78
Field defect	15	23	41
Loss of central vision	38	43	52
None	61	58	22

TABLE VII: REFRACTIVE ERROR IN RELATION TO TYPE OF DETACHMENT

	% of Patients		
Refractive Error	Nontraumatic Dialysis	Traumatic Dialysis	Nondialysis
Aphakia	1	4	44
Emmetropia	33	32	18
Myopia	18	16	26
Hyperopia	48	48	12

NUMBER OF QUADRANTS DETACHED

Despite the frequently long duration of detachment in eyes with a dialysis, 77% of the eyes with nontraumatic dialyses and 71% of eyes with traumatic dialyses had only one quadrant detached, compared with 19% of the eyes in the nondialysis group. All four quadrants were detached in 6% of the nontraumatic dialysis group, 9% of the traumatic dialysis group, and 27% of the nondialysis group. These differences in the number of quadrants detached between the dialysis and nondialysis groups are significant, whereas there is no significance between the two dialysis groups (Table VIII).

DURATION OF DETACHMENT

Table IX summarizes the estimated duration of the retinal detachment at the time of diagnosis in the three groups of patients. The duration used for calculation was the greater of the duration determined from the onset of symptoms or the calculated duration as determined from the number of concentric demarcation lines. The difference in the duration between the dialysis and nondialysis groups is striking. For example, 71% of the non-dialysis patients had a duration of less than one month, compared with only 24% of the traumatic dialyses and 33% of the nontraumatic dialyses patients. Only 4% of the eyes without a dialysis had a duration of greater than

TABLE VIII: NUMBER QUADRANTS DETACHED

	% of Eyes		
Quadrant Detached	Nontraumatic Dialysis	Traumatic Dialysis	Nondialysis
One	77	71	19
Two	10	13	40
Three	7	7	16
Four	6	9	27

TABLE IX: DURATION OF DETACHMENT

Duration	Nontraumatic Dialysis		Traumatic Dialysis		Nondialysis	
1-7 days	14%		20%		41%	
8-14 days	10%	33%	8%	24%	17%	71%
15-30 days	9%		14%		13%	
1-2 mo	11%		15%		13%	
3-6 mo	29%		30%		11%	
7-12 mo	11%		5%		2%	
13-24 mo	6%	26%	4%	14%	1%	4%
< 24 mo	11%		5%		1%	
Average duration	140 days		125 days		21 days	

six months, compared with 14% of eyes with traumatic dialyses and 26% of eyes with nontraumatic dialyses. The average duration in the nondialysis eyes was 21 days; in nontraumatic dialysis eyes, 140 days; and in traumatic dialysis eyes, 125 days.

CYSTS AND DEMARCATION LINES

One or more intraretinal macrocysts were present in 25% of the eyes in the nontraumatic dialysis group, in 13% of the eyes in the traumatic dialysis group, and in only 1.6% of eyes in the nondialysis group (Table X). The incidence of macrocysts increased in a linear fashion with the duration of the detachment in all three groups, but for every duration interval the incidence was significantly greater in eyes with dialyses than in eyes without dialyses (Table XI).

One or more concentric demarcation lines were present in 44% of the nontraumatic dialysis eyes, in 25% of the traumatic dialysis eyes, and in only 10% of the nondialysis eyes (Table XII). The high incidence in the dialysis groups is statistically significant and is further evidene of the prolonged latent period in the group of patients with retinal detachment caused by a dialysis.

TABLE X: INCIDENCE OF INTRARETINAL MACROCYSTS

	% of Eyes		
No. of Cysts	Nontraumatic Dialysis	Traumatic Dialysis	Nondialysis
One	12	8	1.0
Two	6	2	0.4
Three or more	7	3	0.2
Total	25	13	1.6

TABLE XI: INCIDENCE OF INTRARETINAL MACROCYSTS IN RELATION TO DETACHMENT DURATION

Duration	% of Eyes		
	Nontraumatic Dialysis	Traumatic Dialysis	Nondialysis
1-7 days	10	3	1
8-60 days	14	2	2
3 mo-1 yr	36	15	3
360 days +	41	53	9

PERIPHERAL RETINAL DEGENERATION

Peripheral retinal degeneration, such as lattice, myopic, and snowflake, was present in 22.6% of the eyes without a dialysis, in only 3.5% of eyes with a dialysis caused by trauma, and in 4.2% of eyes with a dialysis not related to trauma (Table XIII). The lower incidence of these three types of peripheral degeneration in eyes with dialyses was found to be statistically significant.

In none of the eyes with a dialysis and an associated peripheral degeneration did the surgeon believe that the degeneration was causally related to the retinal detachment. For example, degeneration was usually located in an area of attached retina and was therefore believed to be an incidental finding.

ASSOCIATED FINDINGS

Table XIII also summarizes other associated findings in the three groups of patients. Although preoperative glaucoma was present at a lower frequency in the nondialysis group, the difference was not statistically significant.

There also was no significant difference in the incidence of retinoschisis. As associated cataract occurred with significantly less frequency in the nontraumatic dialysis group than in the other two groups, as did a dislo-

TABLE XII: INCIDENCE DEMARCATION LINES

Number Lines	% of Eyes		
	Nontraumatic Dialysis	Traumatic Dialysis	Nondialysis
One	17	10	6
Two	12	8	3
Three or more	15	7	1
Total	44	25	10

TABLE XIII: INCIDENCE OF ASSOCIATED CONDITIONS

Condition	% of Eyes		
	Nontraumatic Dialysis	Traumatic Dialysis	Nondialysis
Lattice degeneration	2.7	2.5	15.5
Myopic degeneration	1.2	0.8	6.3
Snow flake degeneration	0.3	0.2	0.8
Glaucoma	4.9	12.6	7.6
Bilateral involvement	2.1	0.5	11.2
Detachment ciliary epithelium	0.3	11.5	15.3
Avulsion ciliary epithelium	0	41.5	0.2
Retinopathy of prematurity	0.6	0	0.8
Retinoschisis	2.9	1.4	4.0
Cataract	4.5	12.4	11.0
Uveitis	1.2	3.1	5.8

cated lens. Active uveitis was significantly more frequent in the nondialysis group than in either of the dialysis groups. The incidence of retrolental fibroplasia was not significantly different in the three groups of patients.

The ciliary epithelium was recorded as being avulsed in 41.5% of the eyes with a traumatic dialysis as compared with 0.2% of the eyes without a dialysis, a highly significant difference. Most likely, the nine patients in the nondialysis group listed as having an avulsion of the ciliary epithelium had an associated dialysis that was not visualized, and therefore they were probably placed into the wrong category. Since an avulsion of the ciliary epithelium was one of the criteria for placement of an eye with a dialysis into the traumatic group, it was not present in any of the eyes in the nontraumatic dialysis group.

Extension of the retinal detachment beyond the ora to involve the ciliary epithelium—detachment of the ciliary epithelium—occurred in 15.3% of eyes without a dialysis, 11.5% of eyes with a traumatic dialysis, and 0.3% of eyes with a nontraumatic dialysis. In almost every instance in which the ciliary epithelium was recorded as being detached in eyes with a traumatic dialysis, there was also an avulsion of the vitreous base or the ciliary epithelium or both.

VITREOUS ABNORMALITIES

We do not have exact data on the incidence of posterior vitreous detachment; however, this finding was almost always present in the nondialysis eyes and virtually never present in eyes with a dialysis. Ophthalmoscopically visible vitreous membranes, regardless of their origin, were present in 18% of the eyes with a traumatic dialysis, 11% of eyes without

TABLE XIV: INCIDENCE OF VITREOUS ABNORMALITIES

Condition	% of Eyes Nontraumatic Dialysis	Traumatic Dialysis	Nondialysis
Vitreous membranes	2.3	18.0	11.0
Fixed folds	1.2	6.3	19.0
Massive preretinal proliferation	0.6	5.2	12.4
Vitreous hemorrhage	1.2	16.2	5.8

dialysis, and in only 2.3% of eyes with a dialysis not related to trauma (Table XIV). Fixed retinal folds—star-shaped, radial, or equatorial—are indicative of preretinal organization, and they were present at a significantly less frequent rate in the nontraumatic dialysis eyes. They were present in 1.2% in this group compared with 6.3% of eyes with a traumatic dialysis and 19% of eyes without a dialysis. Fixed folds severe enough to be classified as massive preretinal proliferation (MPP) were observed in only two eyes (0.6%) with a nontraumatic dialysis, whereas this MPP was reported in 5.2% of traumatic dialysis eyes and 12.4% of eyes with dialysis. Vitreous hemorrhage was present in 16.2% of eyes in the traumatic dialysis group, as compared with only 1.2% of eyes in the nontraumatic dialysis group and 5.8% of eyes without a dialysis.

STATUS OF THE MACULA

Although the majority of eyes with a dialysis had only one quadrant detached, the detachment frequently involved the macula. The macula was detached in 66% of the eyes with a nontraumatic dialysis, 67% of eyes with a traumatic dialysis, and 59% of eyes without a dialysis. The increased incidence of macular detachment is not significant at the 0.005 level, but it is significant at the 0.025 level. Cystoid degeneration of the macula or a macular cyst was present ;in 10% of the nontraumatic dialyses, 11% in the traumatic dialyses, and only 4% of nondialysis eyes. Macular hemorrhage

TABLE XV: STATUS OF MACULA

Finding	% of Eyes Nontraumatic Dialysis	Traumatic Dialysis	Nondialysis
Macula detached	66.0	67	59
Macular degeneration or hemorrhage	1.2	6	2
Macular cyst	10.0	11	4

or degeneration was present in 1.2% of the nontraumatic dialyses, 6% of the traumatic dialyses, and 2% of the nondialysis eyes. Included in the group of patients recorded as having macular degeneration were patients with traumatic commotio retinae (Table XV).

RECORDED FAMILY HISTORY OF RETINAL DETACHMENT

There were only two patients (1%) in the traumatic dialysis group who gave a family history of one or more members with a previous retinal detachment of any type. In the nontraumatic dialysis group there were six patients (1.8%) with a positive family history. This compared with 141 patients, or 3.1%, in the nondialysis group.

Ninety-eight questionnaires were returned out of the 250 mailed to patients with retinal dialysis. From these we discovered only two additional persons in families with a nontraumatic dialysis who had a direct family member with a myopic type of retinal detachment. We did not discover a single case of a dialysis in other family members from the questionnaires.

INCIDENCE OF BILATERALITY

One or more retinal tear, with or without a detachment, was present in only seven patients (2.1%) with a nontraumatic dialysis, one patient (0.5%) with a traumatic dialysis, and 541 patients (11.2%) without a dialysis. This tear was a dialysis in four of the seven nontraumatic dialysis patients with bilateral involvement. In the three patients with a tear other than a dialysis, two had a horseshoe tear and one a round hole. In some instances in the nondialysis group there was only a history of retinal tear or detachment in the fellow eye and the type could not be confirmed since the eye had either been enucleated or the media were too opaque. During the 18-year period of this study, we observed that in only one patient did a dialysis develop in the fellow eye subsequent to the initial examination. The low incidence of bilaterality in dialysis patients is statistically significant at the 0.005 level.

ANATOMIC RESULTS

During the early years of this study, 1960 through 1965, diathermy was the only agent used for production of chorioretinal adhesions. Five hundred eighty-nine eyes were treated with this modality. In the majority of cases, it was applied through a partial-thickness scleral bed, beneath scleral flaps, and a variety of solid molded silicone implants were used. An encircling polyethylene tube or a silicone band was placed on top of the implant in

78% of all eyes operated on, and a segmental silicone implant, without an encircling element, was used in 18%. Transscleral diathermy without an implant was utilized in 4% of the eyes operated on. Subretinal fluid was drained in 86% of the eyes with a dialysis and 74% of the eyes without a dialysis.

Following the advent of cryocoagulation, diathermy was abandoned and scleral undermining was no longer performed. Cryocoagulation was used as the cauterizing agent in 4,569 eyes (89%) in this series. Episcleral exoplants of molded silicone, with or without an encircling silicone band, were used in almost all cases. Only rarely was a silicone sponge used, but we do not have information regarding the exact number of eyes operated on with a sponge. In recent years, intravitreal air or sulfa-hexafluoride (SF-6) has been used with increasing frequency, either alone or in conjunction with a scleral buckling procedure. During the past six years, air or SF-6 was used in four eyes with nontraumatic dialyses, 12 eyes with traumatic dialyses, and 289 eyes without dialyses.

In the dialysis groups photocoagulation alone was used in 12 eyes and transconjunctival cryocoagulation alone in 15 eyes, which represents only 5.1% of the total eyes operated on. These modalities were used only to seal retinal tears without a clinical retinal detachment or to strengthen a preexisting demarcation line.

TABLE XVI: ANATOMIC RESULTS

	% of Eyes		
Type Surgery	Nontraumatic Dialysis	Traumatic Dialysis	Nondialysis
Diathermy			
Transscleral	100	100	92
Photocoagulation	100	100	98
Segmental buckle with diathermy	100	80	93
Encircling buckling with diathermy	100	80	96
Cure rate diathermy	100	90	94
Cryocoagulation			
Transconjunctival	100	100	95
Segmental buckle and cryocoagulation	100	95	88
Encircling buckle and cryocoagulation	98	96	94
Cryocoagulation and intravitreal gas	100	81	75
Cure rate cryocoagulation	99	96	92
Overall cure rate	99.4	95.9	92.5
% Requiring more than 1 operation for reattachment	4	9	17

A successful anatomic result or a "cure" was defined as reattachment of the retina with no visible subretinal fluid on or posterior to the buckle at a minimum of three months following surgical treatment regardless of the number of operations required to obtain reattachment. This information was available in 93% of the eyes operated on in this series. Table XVI displays the anatomic results in relation to the type of surgery performed in each of the three groups. There was no statistical difference in the rate of reattachment between those patients treated with diathermy and those treated with cryocoagulation. The overall rate of reattachment with diathermy was 95.1%, and with cryocoagulation, 93.6%. There were only two eyes (0.6%) in the nontraumatic dialysis group that did not obtain successful reattachment, eight (4.1%) in the traumatic dialysis group and 362 (7.5%) in the nondialysis group. It is statistically significant that eyes with a nontraumatic dialysis obtained a higher rate of anatomic reattachment than eyes in the other two groups. It is also significant that both groups of dialysis eyes required fewer operations to obtain reattachment than nondialysis eyes. Traumatic dialysis eyes required more operations than nontraumatic dialysis eyes.

VISUAL RESULTS

The preoperative and postoperative visual acuity was available in 89% of the patients in this series. In the 1,710 eyes operated on during the early years of this series, the visual acuity measurements were broken into only eight divisions, from 20/20 to light perception. The checksheet was subsequently modified, and in 3,650 eyes the preoperative and postoperative measurements were broken down into 14 subdivisions, from 20/15 to no light perception. Each of those later divisions is referred to as "one line" although "one line" did not always subtend the same visual angle, for example, between division 20/20 and 20/15 and 20/400 and 5/200.

It is appropriate to analyze the visual results only in the eyes that obtained an anatomic reattachment. In the eyes obtaining reattachment, vision was improved in 62% of the eyes in the nontraumatic dialysis group, 68% of eyes in the traumatic dialysis group, and 55% of the nondialysis eyes (Table XVII).

TABLE XVII: FINAL VISUAL ACUITY IN ALL EYES WITH RETINA SUCCESSFULLY REATTACHED

Final Visual Acuity	Nontraumatic Diaylsis	Traumatic Dialysis	Nondialysis
Unchanged	33%	28%	39%
Improved	62%	68%	55%
Diminished	5%	4%	6%

TABLE XVIII: FINAL VISUAL ACUITY IN EYES WITH PREOPERATIVE VISION 20/200 OR WORSE

Final Visual Acuity	Nontraumatic Dialysis	Traumatic Dialysis	Nondialysis
20/50 or better	32%	42%	46%
20/50 or worse	68%	58%	54%

As mentioned earlier, the macula was detached more frequently in both of the dialysis groups and the preoperative vision correlated with this. The preoperative acuity was 20/200 or less in virtually all patients with a macular detachment. In the nontraumatic dialysis group the preoperative visual acuity was 20/200 or less in 60%; in the traumatic dialysis group, 51%; and in the nondialysis group, 49%. In these patients with a preoperative visual acuity of 20/200 or less, the final visual acuity returned to 20/50 or better in 32% of the eyes with nontraumatic dialyses, 42% of eyes with traumatic dialyses, and 46% of eyes without dialyses (Table XVIII).

From Table XIX it can be seen that there was only a slightly higher percentage of eyes in the dialysis groups obtaining one or more lines of visual improvement than in the nondialysis group; statistical analysis indicated this was due to the fact that there were more eyes in the dialysis group with impaired preoperative central vision and, therefore, more eyes were available for visual improvement. Naturally those eyes with a normal preoperative acuity could not gain any improvement following successful surgical treatment. Analysis of the visual results of those patients with a preoperative acuity of 20/200 or less revealed the number of lines of improvement was greater in those eyes without dialysis. Seven or more

TABLE XIX: LINES VISUAL IMPROVEMENT IN EYES WITH RETINA SUCCESSFULLY REATTACHED

	% of Eyes		
No. of Lines Improvement	Nontraumatic Dialysis	Traumatic Dialysis	Nondialysis
None	29	25	31
1	9	19	10
2	13	7	6
3	10	9	7
4	15	8	9
5	7	12	9
6	4	9	6
7	4	1	5
8	2	4	4
9	2	3	4
10	4	3	4
11	2	0	3
7 or more lines improvement	14	11	20

lines of visual improvement occurred in 14% of the nontraumatic dialysis eyes, 11% of the traumatic dialysis eyes, and 20% of the nondialysis eyes. Further multifactorial analyses indicated the increased visual improvement in the nondialysis eyes was related only to the shorter duration of detachment in this group.

In summary, although there were slightly more eyes inthe dialysis group that obtained visual improvement following retinal reattachment, this was not statistically significant. There were more eyes in the dialysis group that had macular detachment with preoperative reduction of vision to 20/200 or less, and the proportion of these eyes obtaining 20/50 or better vision was slightly, but significantly, less than the group of eyes without a dialysis. This was found to be related to the longer duration of detachment prior to surgical treatment in the dialysis groups, and not to any other factors we could identify.

COMPLICATIONS

The most frequently occurring major complications are tabulated in Table XX. There were few significant differences noted among the three groups. Postoperative glaucoma was recorded in a slightly higher percentage of eyes in the traumatic dialysis group, but this group had a higher incidence of preoperative glaucoma. Because our follow-up period was only three months for a number of eyes, we did not believe tests for significance would be meaningful, since glaucoma may not develop until after this period. The only complication that was statistically significant was the increased occurrence of postoperative massive periretinal proliferation in the eyes without dialysis.

RESULTS OF QUESTIONNAIRE

As mentioned previously, a detailed questionnaire regarding family history

TABLE XX: INCIDENCE OF COMPLICATIONS

	% of Eyes		
Complication	Nontraumatic Dialysis	Traumatic Dialysis	Nondialysis
Choroidal hemorrhage	1.5	2.5	2.5
Subretinal hemorrhage	5.6	1.0	6.4
Infection	1.2	1.5	0.9
Glaucoma	1.9	3.5	1.1
Macular pucker	2.8	3.0	4.5
Massive preretinal proliferation	0.9	2.5	4.5
Failure to reattach	0.6	4.1	7.5

and ocular trauma history was mailed to 224 dialysis patients, both traumatic and nontraumatic, who had the most recent surgical treatment; 98 questionnaires were returned. The results were tabulated, and in only two patients was new informatin obtained relative to a sibling with a previous retinal detachment whom we did not have on our original list. Neither of these siblings had a dialysis. Three patients returned evidence of what we considered to be a verified history of an ocular contusion; we had previously listed these patients as having a nontraumatic dialysis. We did not uncover a single case in which there appeared to be important evidence of unusual birth trauma, prenatal maternal drug intake, or evidence of a maternal illness that might have been significant in the production of a dialysis in a newborn. Except for three families who recorded family members with mental deficiency, no other known inherited abnormality was noted with frequency. There were three new family histories of stabismus and one of deafness. Consanguinity was not indicated on any of the returned questionnaires.

RESULTS OF GENETIC EVALUATION

We performed a complete ophthalmologic evaluation with emphasis on peripheral fundus changes on 70 members of nine families randomly selected from patients with nontraumatic dialysis. Sixty-two members of seven of these families also had a complete systemic history, physical examination, and genetic evaluation performed by an independent geneticist. In addition, a detailed biochemical urinalysis screening evaluation was performed to detect any of the abnormal metabolites known to be associated with a variety of inherited disorders. The tests routinely included amino acid electrophoresis; tests for reducing substances; and nitroprusside, ferric chloride, toluidine blue, nitrosonaphthol, and methylamalonic acid tests.

There were no abnormal physical or urinary findings in any of these 62 family members. Simplified pedigrees prepared by the geneticist are depicted in Fig 5, A through G. In families 5 A and 5 B, because of the evidence of retinal detachment in other family members, chromosomal analysis was performed and no abnormal karyotypes were observed.

We are aware that our sample of only nine of the nontraumatic dialysis families is rather small, but in view of the lack of positive findings and the difficulty and expense involved in having families return for these detailed studies, as well as the negative results from the questionnaire, both the geneticist and the statistician believed that there would be little chance of

KEY — FOR FIGURE 5

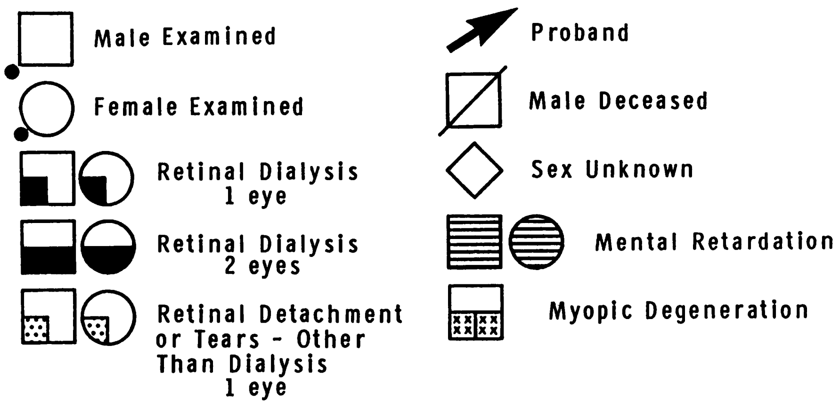


FIGURE 5

A: 22-year-old white man with unilateral nontraumatic lower temporal dialysis. Father had history of previous unilateral retinal detachment secondary to dialysis, and on examination he was found to have three-minute dialyses, each smaller than one ora bay, in the lower temporal quadrant of his fellow eye. Patient's two brothers had no significant abnormalities. Paternal grandmother had history of an unoperated retinal detachment but she was not available for examination. Since her detachment developed at age 62, it is not likely this had been related to a dialysis. Chromosomal analysis was normal. B: 12-year-old white girl with unilateral lower temporal nontraumatic retinal detachment OD. Two siblings were examined and no ocular abnormalities noted. One of these had mental retardation. Neither parent had ocular abnormalities. A maternal great aunt had retinal detachment, most likely caused by branch vein occlusion. Chromosomal analysis was normal. C: 18-year-old white woman with unilateral nontraumatic lower temporal retinal dialysis OD. No ocular abnormalities were noted in 14 family members examined. III-1 reported to have had optic atrophy produced from forcep injury at birth and III-15 congenital strabismus. Refractive errors varied from − 1.50 to + 2.00 in family members. D: 15-year-old white boy with unilateral lower temporal dialysis right eye. Small retinal hole near ora was present in left eye. One brother had congenital bilateral retinal tags. Seven family members were examined; none had other retinal abnormalities. E: 7-year-old white boy with unilateral dialysis OS. His two half siblings were examined and no abnormalities were detected. Father had high hyperopia and was found to have minute peripheral excavation at 12-o'clock position and marked peripheral cystoid degeneration. Patient's mother married her first husband's brother. Materanl uncle had strabismus, but no other family members examined had ocular abnormalities. F: 15-year-old white girl with unilateral nontraumatic retinal detachment caused by lower temporal retinal dialysis. Three siblings and nine other direct family members were examined and no ocular abnormaliteis were detected. G: 18-year-old white man with unilateral lower temporal dialysis. This was classified as nontraumatic although patient had previous lid laceration from automobile accident nine years previously. Refractive error of − 3.00 OD. Both siblings were myopic as was father, but mother was hyperopic. No retinal abnormalities were noted on 12 family members examined except for myopic degeneration in two brothers.

P.W.

FIGURE 5A

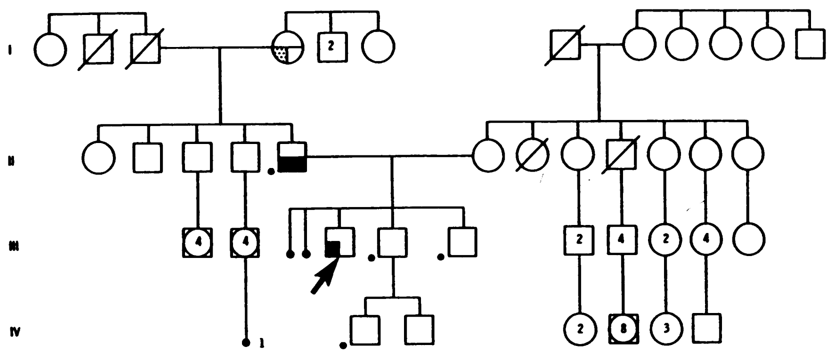


FIGURE 5B

E.W.

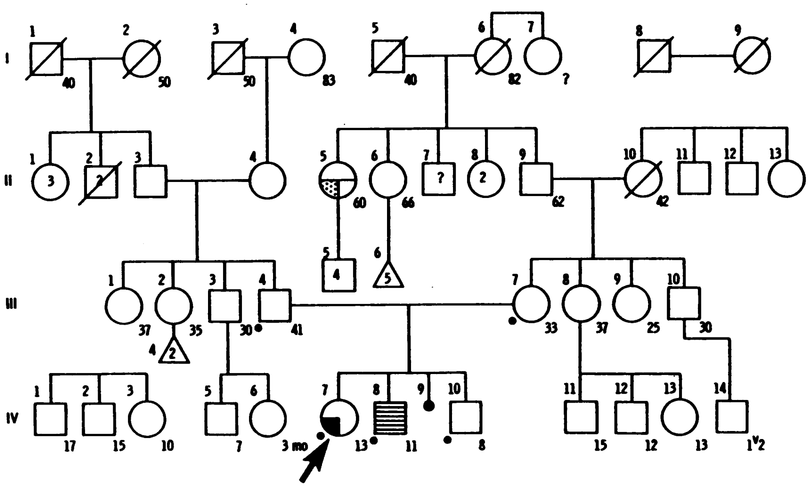


FIGURE 5C

R.G.

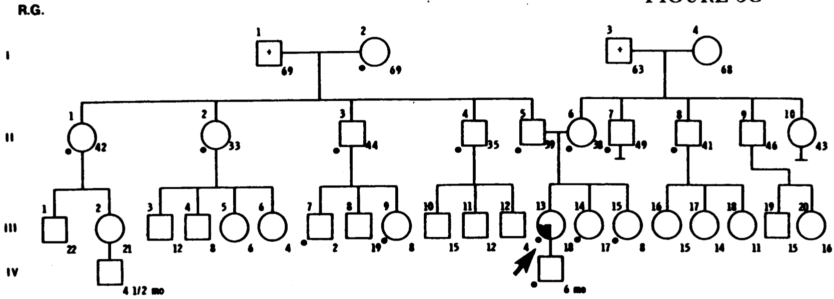


FIGURE 5D

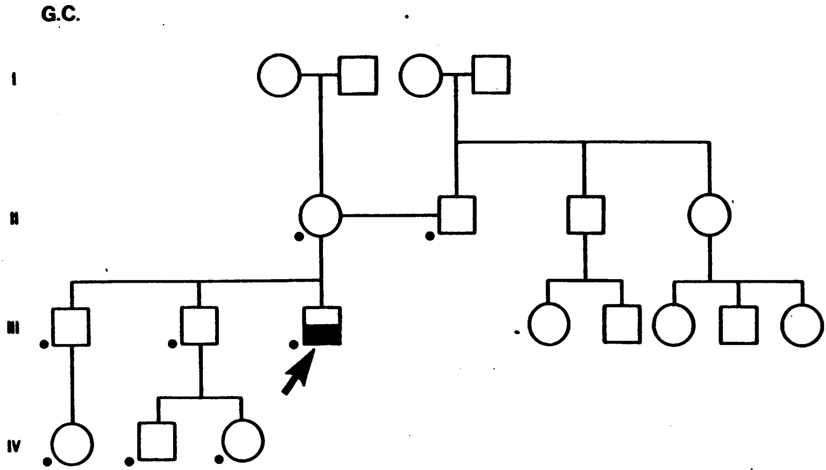


FIGURE 5E

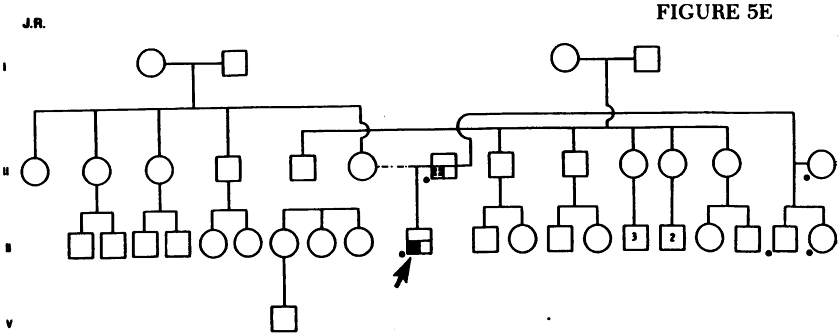


FIGURE 5F

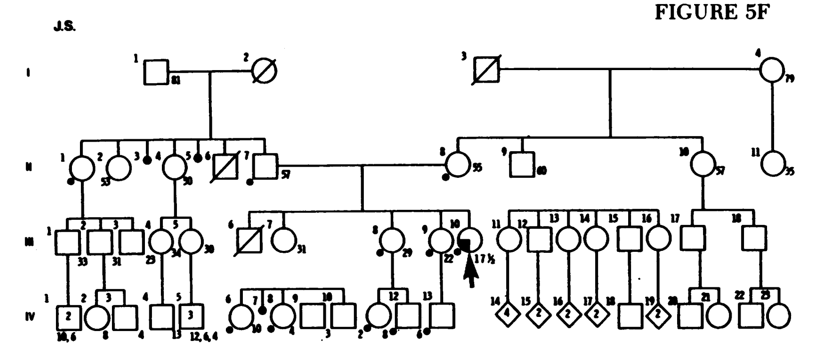
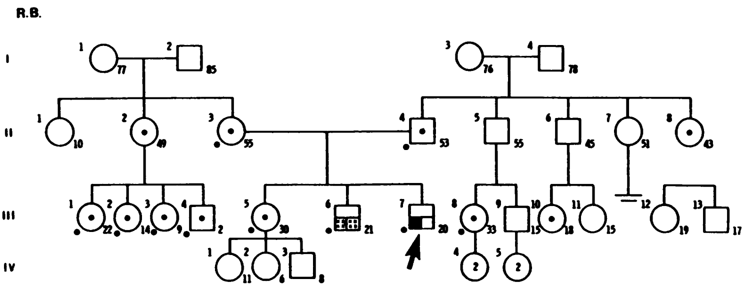


FIGURE 5G



obtaining additional valuable information by examination of a larger sample of families.

DISCUSSION

INCIDENCE

The incidence of dialysis reported in most previous studies of retinal detachment of all ages[8,18-22,32,33] varies from 8% to 17% (Table XXI). It has been well documented that a dialysis is the major type of retinal tear causing a retinal detachment in children.[7,16,24,28,34-36] The reported incidence of dialysis in patients under the age of 20 with retinal detachment varies from 19% to 51%. Similarly, in this series, of the eyes with retinal detachment in those patients 20 years of age or younger, 43% contained a dialysis.

TABLE XXI: INCIDENCE OF DIALYSIS

Author	Year	Incidence of Dialysis
Shapland[8]	1949	33% of 164 retinae detachments (RD)
Leffertstra[18]	1950	14% of 1,428 RD
Tornquist[22]	1963	17% of 672 RD
Tulloch[32]	1965	10.9% of 442 RD
Donaldson[21]	1967	15% of 667 RD
Hagler and North[19]	1968	10% of 1,352 RD
Hilton and Richards[37]	1970	69% of 26 RD
Chignell[20]	1973	8% of 824 RD
Rodriguez[33]	1972	19% of 1,103 RD
Chang	1979	20% of 502 RD
Hilton and Norton[34]	1969	27% of RD < age 20
Hudson[24]	1969	51% of RD < age 20
Gailloud et al[7]	1969	19% of RD < age 20
Richardson[28]	1969	25% of 118 RD < age 20
Chen and Dumas[23]	1972	43% of RD < age 20
Winslow and Tasman[16]	1978	40% of RD < age 16
Scharf and Zonis[36]	1973	29% of RD < age 20

Our series of 523 dialyses is more than twice as large as any previously reported, and our incidence of dialysis of 9.8% of 5,360 eyes with retinal detachment is about the average of those other series composed primarily of North Americans or Western Europeans. It must be remembered that we included all eyes with a dialysis in a dialysis group, even if additional tears of other types were present. On the other hand, we included those dialyses that were produced from contraction of vitreous membranes following penetrating trauma, vitreous loss from intraocular surgical treatment, and chorioretinal inflammatory disease. We were careful to exclude giant tears. Most of the previously reported studies did not specifically state whether dialyses resulting from these diverse causes were included and giant tears were obviously included in many series. It is doubtful that the small subtle anterior dialyses could have been detected prior to the development of indirect ophthalmoscopy and scleral depression. In addition, it is assumed that, with the advent of newer diagnostic and therapeutic techniques, many more eyes with detachment are being subjected to surgical treatment now than in the past. These reasons may explain the variation of incidence in reported series, and they make it impossible to make any meaningful comparison between the incidence of dialysis in this series and the other published series.

In Rodriguez series[33] of 1,103 retinal detachments there was a 19% incidence of dialysis, and this series was apparently composed of a high percentage of Colombian Indians. Hilton and Richards[37] reported that the incidence of dialyses was 69% in 26 eyes operated on for retinal detachment in American Indians. M. Chang, MD, reported a 20% incidence of dialysis in Chinese patients operated on for retinal detachment, 20% of whom had bilateral involvement (oral communication, December 1979).

These three reports, therefore, indicate that some racial or ethnic factors may account for the high incidence of dialysis in non-Caucasians. Future investigations may be able to identify these factors and may provide additional information regarding the etiologic basis of retinal dialysis.

ROLE OF TRAUMA

From the analysis of our data, it was relatively easy to place the majority of dialysis eyes into either a traumatic or nontraumatic group. We had information regarding the presence or absence of accepted trauma signs as well as information relative to the severity of the patient's trauma as obtained from the history. In 71% of 191 eyes in the trauma group, there was at least one sign of previous ocular trauma, and the remaining 29% gave a history that we believed was sufficiently valid to permit inclusion in the trauma group. This high incidence (37%) of trauma signs and history in the dialysis group was statistically significant compared with the nondialysis group, in which trauma signs or a verified history occurred in only 152 eyes or 3.1%. We included the 41 eyes with only a history of mild trauma to the eye, head, or neck without any trauma signs in the nontraumatic dialysis group. If they had been placed into the traumatic group, then this group would have comprised 44.3% instead of 36.5% of the total eyes undergoing surgical treatment. Sample statistical studies showed that there would have been no significant change in the results if this change in classification had been utilized.

In the entire series of 5,360 eyes, trauma was ascribed as the cause of detachment in 6.4%, and of these a dialysis was by far the most frequent type of tear present, occurring in 55.7% of the traumatic detachments. This is almost the same as the 59% incidence of dialyses reported by Cox et al[11] in their series of 160 patients with traumatic retinal detachment.

A certain amount of subjective interpretation regarding the significance of the history had to be used in making the decision regarding classification into the traumatic and nontraumatic groups. By the act of separating all dialysis eyes into traumatic and nontraumatic groups, we do not intend to imply that indeed the trauma caused or did not cause the dialysis. Even if a patient had a verified history of a significant injury with a sign such as hyphema, we still have no way of determining whether the trauma actually caused the dialysis, since the dialysis could have been preexisting. In almost all cases the patient was not examined until months or years after the injury had occurred.

Tasman,[38] however, did find that in 19% (10) of 52 patients, a dialysis developed immediately following a contusion injury. Sellors and Mooney[39] detected dialyses in only 3% (2) of 60 eyes with a hyphema following

TABLE XXII: RELATIONSHIP OF TRAUMA TO RETINAL DIALYSIS

Author	Year	Findings
Leffertstra[18]	1950	21% of 199 dialyses caused by trauma
Cox, Schepens and Freeman[11]	1966	28% of 83 dialyses caused by trauma Dialysis in 55% of 160 traumatic retinal detachments
Shapland[8]	1949	39% of 54 dialyses caused by trauma
Donaldson[21]	1967	23% of 101 dialyses caused by trauma
Gailloud et al[7]	1969	34% of 83 dialyses caused by trauma
Hudson[24]	1969	58% of 31 children—trauma history
Hagler[19]	1968	41% of 135 dialyses—history or signs of trauma
Rodriguez[14]	1972	58% of 43 dialyses—trauma history
Tasman[38]	1972	19% of 52 eyes with contusion ⟶ dialysis
Sellors and Mooney[39]	1973	3% of 60 eyes with hyphema ⟶ dialysis
Eagling[40]	1974	5% of 109 contusion ⟶ dialysis

nonpenetrating trauma, and Eagling[40] found dialyses occurred in 5% of eyes that had been hospitalized following blunt trauma. Gailloud[7] believed trauma was responsible for 73.4% of dialyses in children, and Hudson[24] believed trauma was responsible for the dialysis in 58% (18) of 31 patients under the age of 20 with a dialysis.

We included avulsion of the vitreous base or ciliary epithelium as one of the objective signs of trauma, and this was present in 106 (56%) of the 191 traumatic dialyses. This decision was based on the research of Weidenthal and Schepens[12] on hog eyes, which clearly demonstrated that this was a frequent occurrence following ocular contusion to the center of the cornea. Table XXII summarizes the incidence of trauma in various series of dialyses previously reported.

In 11.2% of the nondialysis patients there were bilateral tears or detachment requiring surgical treatment, whereas only 2.1% of the nontraumatic group had bilateral tears. There was only one patient (0.5%) of the 189 patients with traumatic dialysis who had a retinal detachment or tear in the fellow eye. Since direct ocular injuries are rarely bilateral, the low frequency of bilaterality in all dialysis patients is evidence in favor of a traumatic causation and is evidence against an inherited causation.

SEX

In the nondialysis eyes the ratio of men to women was 56 to 44, slightly greater than in the general population. As shown in Table V, in the dialysis group there was an increased proportion of men to women of 69 to 31, which was statistically significant. This higher incidence of men was primarily due to the much higher proportion of men in the traumatic dialysis group, where the ratio was 84 to 16, compared with the ratio of 60 to 40 in the nontraumatic dialysis group. The increased incidence of men in the traumatic dialysis group might be a result of their more physical lifestyle. The fact that the incidence of men is also significantly higher than women in the nontraumatic dialysis group suggests that trauma could be a cause of the dialysis in a large number of this group even though neither trauma signs nor trauma history were recorded in this group.

RACE

The incidence of nonwhite patients was three times greater (12%) in the traumatic dialysis eyes than in the nondialysis eyes (4%) and almost twice as great (7%) in the nontraumatic dialysis eyes. There may be some racial or ethnic factors in the etiology of dialyses, but as yet they have not been identified.

AGE

As shown in Fig 6, dialyses, both traumatic and nontraumatic, occur at a significantly earlier age than do other types of tears. The average age of patients without a dialysis was 66 compared with 32 of those with nontraumatic dialyses and 24 of those with traumatic dialyses. In the traumatic dialysis group, 49% were aged 20 or younger, compared with 30% of the nontraumatic dialysis group and only 5.6% of the nondialysis group. Expressed another way, of all retinal detachment patients reported in this study who were aged 20 or younger, 43% had a dialysis. This young age of onset is similar to numerous other reported series[7,16,24,28,34-36] and indicates that the majority of dialyses result from trauma or from some undetermined familial or genetic factors, or both, and that they are not produced by the vitreoretinal degenerative disorders that produce most other forms of retinal detachment that become manifest later in life.

SYMPTOMS

No symptoms were reported by 61% of the patients in the nontraumatic dialysis group and 58% in the traumatic dialysis group. This high proportion without symptoms is statistically significant in comparison to the nondialysis group, in which only 22% failed to report symptoms. Our data would indicate that the low incidence of symptoms is a result of the following factors: (1) the absence of vitreous detachment, (2) the slow progression of subretinal fluid, (3) the absence of vitreous traction, (4) characteristic involvement of the superior visual field, and (5) the occurrence in some patients too young to accurately report symptoms. It is impossible to weigh the relative importance of those factors from our data, and indeed there may be additional factors. This absence of symptoms in such a high percentage of patients should remind us that if a retinal dialysis is to be diagnosed at an early stage, indirect ophthalmoscopic examination with scleral depression will have to be performed on a large number of asymptomatic young patients. This would be valuable as a routine part of an eye examination, especially in those patients who have been subjected to ocular trauma.

REFRACTIVE ERROR

The low incidence of aphakia of 2.5% in both dialysis groups compared with a 44% incidence in the nondialysis group is statistically significant. Hyperopia and emmetropia were present significantly more frequently and myopia less frequently in the dialysis groups. The low incidence of myopia in eyes with dialyses is additional evidence that dialyses are not caused by the usual vitreoretinal degenerations that are more frequent in myopic eyes and that cause so many other types of retinal detachment.[41]

DURATION OF DETACHMENT PRIOR TO DIAGNOSIS

It was determined that the longer latent period between the onset of symptoms and the diagnosis of the retinal detachment of 130 days in both of the dialysis groups as compared with 21 days in the nondialysis group was statistically significant (Table IX).

Since the majority of patients with dialysis had no symptoms or were too young to report them accurately, the recorded duration of symptoms may not coincide with the actual onset of the detachment. We used the greater of either the onset of symptoms or the duration as calculated from the number of concentric demarcation lines, assuming that it takes a minimum of three months for each demarcation line to form.[18]

There is a striking increase in the prevalence of dialysis in the total group of retinal detachment as the duration of the retinal detachment increases (Table XXIII). In the detachments under two weeks' duration, dialyses were present in only 5%, whereas in those with a duration one year or longer, dialyses were present in 22%.

Multifactoral statistical testing indicated that the prolonged duration was the major factor accounting for the increased incidence of macular detachment, macular degeneration, macular cysts, and the diminished number of lines of visual improvement in the dialysis group.

The prolonged duration also correlates in a linear fashion with the statistically significant increased incidence of demarcation lines in eyes with dialysis. Demarcation lines were present in 45% of the nontraumatic dialyses, 25% of traumatic dialyses, and in only 10% of the nondialyses.

Lefertstra,[18] using indirect evidence, showed that a detachment must be stationary for at least three months for a demarcation line to form. It must be emphasized that if a patient had no symptoms and a single demarcation line, he was recorded as having a detachment of only three months'

TABLE XXIII: INCIDENCE OF TYPE OF DETACHMENT IN RELATION TO DURATION

Duration of Detachment	Nontraumatic Dialysis	Traumatic Dialysis	Nondialysis
1–7 days	1.5%	2.0%	96.5%
8–14 days	3.1%	2.0%	94.9%
15–30 days	3.5%	4.5%	92.0%
1–2 mo	3.6%	4.4%	92.0%
3–6 mo	9.7%	9.9%	80.4%
7–12mo	15.1%	5.4%	78.0%
13–24 mo	20.0%	2.4%	77.6%
>24 mo	21.1%	13.5%	65.4%

duration, when in actuality his detachment could have been present for many years. Therefore, all the time intervals used in our calculations relating to duration must be considered as minimum.

When the progression of the subretinal fluid is slow enough to permit a demarcation line to develop between the pigment epithelium and the neurosensory retina, it may effectively seal off the peripheral subretinal fluid from the posterior pole. Months or years later, from causes not clearly understood, a portion of this demarcation line may break down and another incremental increase in the detachment may occur. Since the incremental increases may be small, the patient may not become aware of his visual field defect until the macula is finally detached. This must occur commonly since in the group of dialysis eyes with demarcation lines, more than one demarcation lines was present in 61%.

INTRARETNAL CYSTS

Intraretinal cysts were present in only 1.6% of the nondialysis eyes compared with 25% of the nontraumatic dialysis eyes and 13% of the traumatic dialysis eyes (Table X). The high incidence in eyes with a dialysis is statistically significant. Statistical tests showed that the high incidence of cysts was related only to the duration of the detachment and not to age, race, sex, or type of tear. The incidence of cysts increased in all three groups in a linear fashion with the duration of the detachment, although the incidence was always significantly less in the nondialysis group of eyes. This could be due to inaccuracy in the recorded duration or to some factor in dialysis eyes not yet identified.

Cysts were 3.2 times more common in patients with one or more demarcation lines than in patients without demarcation lines, and the average duration of detachment in patients with cysts was significantly longer than in patients without cysts.

We believe these statistics provide strong evidence that the intraretinal cysts are the result of a degenerative phenomenon that occurs in long-standing retinal detachment from any cause, as first reported by Hagler and North.[42] There is no evidence from our data to indicate that intraretinal cysts produce the dialysis, as has been reported by others.[25,26,28,42-44] A retinal macrocyst in the absence of a retinal detachment has never occurred in our experience.

STATUS OF VITREOUS AND ASSOCIATED FINDINGS

Ophthalmoscopic and slit-lamp examination of the vitreous showed that in every eye with a posterior dialysis, the vitreous was attached to the posterior edge of the dialysis and that there was no visible posterior vitreous detachment. In most instances we could visualize a faint membranous structure extending from the posterior edge of the dialysis to the ciliary epithelium. This may represent the intact posterior hyaloid bridging the dialysis. In some cases there appeared to be some lacunae or fibrils with or without condensation strands within this structure, but our clinical methods of examination do not permit us to determine accurately whether the hyaloid is intact or whether it contains small perforations. In the absence of a posterior vitreous detachment we could not determine accurately the exact location of the posterior attachment of the vitreous base, but frequently there was a faint ridge approximately 1 or 2 mm posterior to the posterior edge of the dialysis, and we believe that this represents the posterior attachment of the vitreous base. There was seldom any visible vitreous bands or membranes in the nontraumatic posterior dialysis eyes, nor were there any fixed folds or evidence of preretinal organization. Frequently there were small light brown pigment globules in the inferior vitreous base, but these have no known adverse effect and their origin is unknown.

The absence of vitreous liquification, preretinal organization, and vitreous membranes in the nontraumatic dialysis group is additional evidence that the vitreous changes are not the cause of the dialysis. Of course, there could be some subtle alteration present in the vitreous that would be visible only on microscopic examination, but there have been no reports of this. Unfortunately, we do not have any pathologic material available for microscopic study.

There is evidence that vitreous traction can result in detachment of the ciliary epithelium.[12,45] The ciliary epithelium was detached in only 0.3% of the eyes in the nontraumatic dialysis group compared with 11% of the eyes in the traumatic dialysis group and 15% of eyes in the nondialysis group. Therefore, this is additional evidence that nontraumatic dialyses do not result from vitreous traction.

As we have reported in other sections of this report, anterior dialyses may be related to vitreous traction bands from any cause, and therefore, vitreous organization occurs not infrequently in these eyes with a dialysis in the ciliary epithelium.

The higher incidence of glaucoma in the traumatic dialysis group is significant and was found to be related to the high percentage of patients who had contusion injury with recession of chamber angle. The fact that the known retinal degenerations occur significantly less frequently in eyes with a dialysis is evidence that dialyses do not result from these degenerations. Retinoschisis was rarely present in either eye in dialysis patients, and this therefore should disprove the frequently reported theory[2,8,32,43,44] that dialyses may result from retinoschisis.

LOCATION OF DIALYSIS

In 171 (33%) of the eyes with dialyses the dialysis was primarily located anterior to the ora in the ciliary epithelium, and in 352 (67%) the dialysis was located posterior to the ora in the peripheral retina. All but 18% of the dialyses located anterior to the ora were due to trauma: 71% of these were secondary to a contusion injury and 38% were secondary to a previous penetrating injury with or without a retained intraocular foreign body. In 5% of the eyes with anterior dialysis the dialysis was secondary to previous chorioretinal inflammatory disease, in 6% the dialysis occurred in aphakic eyes with evidence of vitreous loss, and in 6% there was proliferation retinopathy.

In the eyes with posterior dialyses, only 14% were caused by trauma and all of these were secondary to contusion injury. Two percent of the eyes were aphakic without evidence of vitreous loss. The remaining 84% had no obvious cause for the dialysis (Table XXIV).

When the quadrant location of the largest dialysis in each eye was tabulated, regardless of whether this was anterior or posterior to the ora, it was determined that 66% of all upper nasal dialyses were traumatic in origin and 53% of the lower nasal dialyses were traumatic. On the temporal half of the globe, the majority of dialyses were nontraumatic in origin, 63% of the upper temporal dialyses and 78% of the lower temporal quadrant were nontraumatic (Fig 2). The same data can be expressed by stating that 66% of the nontraumatic dialyses are located in the lower temporal quadrant and only 14% in the upper nasal quadrant. On the other hand, 46% of

TABLE XXIV: CLASSIFICATION OF DIALYSIS

Location	No. of Eyes	% of Group	% of Total Dialysis Eyes
Anterior to ora			
Postcontusion injury	91	54	18
Postpenetrating injury	59	32	10
Postinflammatory	7	5	1
Postvitreous loss	10	6	2
Postproliferative vascular	4	6	1
Total anterior	171	100	33
Posterior to ora			
Postcontusion injury	49	14	9
Idiopathic	298	84	57
Aphakia without vitreous loss	5	2	1
Total posterior	352	100	67

the traumatic dialyses are located in the upper nasal quadrant and 30% in the lower temporal quadrant. It is statistically significant that the majority of nontraumatic dialyses are located in the lower temporal quadrant and that traumatic dialyses are located both in the upper nasal quadrant and lower temporal quadrant.

SURGICAL RESULTS

Cryocoagulation was used in 89% of all eyes operated on and diathermy in 11%. There was no statistically significant difference between the rate of reattachment related to the stimulating agent, diathermy, or cryocoagulation. There could not be any bias in the decision to use diathermy or cryocoagulation since diathermy was used exclusively during the first four years of this study, and cryocoagulation was used exclusively during the last 14 years.

The anatomic reattachment rate in eyes with nontraumatic dialysis was 99.4%, with traumatic dialysis 95.9%, and eyes without dialysis 92.5%. The high reattachment rate in nontraumatic dialysis eyes is statistically significant when compared with the other two groups. In addition, multiple operations to obtain reattachment were performed significantly less often in both dialysis groups than in the nondialysis group.

We did not perform statistical tests comparing the patients who underwent encircling buckling procedures, segmental buckling procedures, and no buckling procedures. The majority of all patients in this series did have an encircling procedure, and there were not enough operative failures to perform meaningful statistical tests. In addition, there is a large amount of bias present, since we use encircling procedures in those patients who we believe have a poor prognosis and nonbuckling or segmental procedures in those who we believe have a more favorable prognosis. However, our data do show a trend for a higher rate of reattachment in the dialysis groups in those patients operated on with an encircling buckling procedure.

The reattachment rate was significantly lower in those patients who required either intravitreal gas or air injection. The injections were used almost exclusively in those eyes with organized vitreous membranes or other evidence of severe vitreous traction, and these findings were invariably in the traumatic group of dialyses or in those eyes with previous inflammatory disease. We also used intravitreal injections in the few eyes that developed large gaping radial folds following drainage of subretinal fluid, the so-called fish mouth effect, but this was a rare occurrence in eyes with a dialysis.

It is my clinical impression that the subretinal fluid in dialysis patients is more viscous than in nondialysis patients, and if residual fluid is present it absorbs more slowly than in nondialysis patients. We do not have data to confirm the rate of fluid absorption, nor have we made any attempt to measure the viscosity of subretinal fluid. This has influenced us to drain subretinal fluid frequently in dialysis patients; this was performed in 89% of the dialysis patients and 71% of the nondialysis patients. We did not have to drain an intraretinal macrocyst in a single instance to obtain reattachment. Therefore, we disagree with Marcus and Aaberg,[46] who stated this is occasionally necessary. In every instance in this series the intraretinal cysts disappeared during the immediate postoperative period, as reported by Hagler and North.[42]

Because there is minimal, if any, vitreous traction or organization in the group of patients with nontraumatic posterior dialyses, at the present time we advocate using either a small segmental exoplant or simple drainage of fluid with saline replacement. We believe this will give a more physiologic result with fewer operative and postoperative complications. An encircling procedure will induce approximately 2 to 3 diopters of myopia,[47] which can be a distressing development to these previously emmetropic patients. In addition, there is a risk of eventual intrusion of an encircling element, especially in young patients who can expect to live 40 to 50 years following their detachment surgery. Leffertstra[18] reported a 95% rate of anatomic reattachment in a group of 200 patients operated on without a buckling material.

Analysis of major operative and postoperative complications failed to reveal any major differences between those patients operated on with cryocoagulation and those operated on with diathermy; therefore, these data are not presented. Subretinal hemorrhage occurred significantly less frequently and glaucoma more frequently in the traumatic dialysis group than in the nontraumatic dialysis group, but otherwise there were no statistically significant differences noted among the three groups. This increased occurrence of postoperative glaucoma was related to the increase incidence of preoperative glaucoma in those eyes subjected to trauma, but we did not perform any analysis that could substantiate this hypothesis.

There are indications for pars plana vitrectomy in a small percentage of the patients who had significant vitreous organization following perforation, choroiditis, or vitreous loss from surgical intervention. Ryan and Allen[13] showed in their animal models that a dialysis of the ciliary epithelium can develop as early as six days following ocular perforation and that this can be prevented by early vitrectomy. In general, we perform vitrectomy only after a standard scleral buckling procedure has failed and only if we are convinced that the traction from the vitreous membrane is preventing reattachment. Vitreous surgical therapy was available only during the last four years of this study and was used in only 11 instances in eyes with dialyses. Because of this small number we did not perform any statistical studies on these eyes. We firmly believe there is a role for vitrectomy and that this procedure will enable some eyes otherwise incurable to be salvaged.

VISUAL RESULTS

In the total group of patients obtaining an anatomic reattachment, vision was improved in 62% of the nontraumatic dialysis eyes, 68% of the traumatic dialysis eyes, and 55% of the nondialysis eyes. Vision was unchanged in approximately 30% of the dialysis and 39% of the nondialysis groups. Final acuity was diminished in approximately 5% of all groups (Table XVII). These differences in visual improvement were not statistically significant. However, if we determine the visual improvement in those eyes in which the macula detached, 46% obtained 20/50 acuity or better in the nondialysis group, compared with only 34% in the dialysis groups (Table XVIII). This higher rate of visual improvement in nondialysis eyes is statistically significant. This was found to correlate directly with the prolonged duration of the detachment in the dialysis groups, since the percentage of eyes obtaining 20/50 acuity or better decreased in a direct relation to the duration of the detachment in each of the three groups. Seven or more "lines" of visual improvement occurred in 14% of eyes with nontraumatic dialyses, 11% of eyes with traumatic dialyses, and 20% of the eyes without dialyses (Table XIX), and the higher rate of visual improvement in the nondialysis group was statistically significant.

ROLE OF HEREDITY IN PATHGENESIS

Several articles in the literature purport to show possible genetic factors in the production of dialyses, but these are somewhat contradictory, confusing, and inconclusive.[15,18,25,29,33,48-50] Francois[25,26] emphasized the difficulty of distinguishing between an essentially hereditary disease and one essentially exogenous in origin because the clinical and functional signs are frequently identical. This helps explain why there is no general agreement as to whether the large number of dialyses that are not caused by trauma or other obvious causes are caused by prenatal or postnatal environmental factors or by some inherited factors, or by a combination of both.

An inherited origin for formation of retinal dialysis would be supported if there were a dialysis in two or more members of a given sibship, and especially if a dialysis were present in several generations of direct family relatives. Francois[25,26] stated that bilateral involvement and the absence of signs of preexisting trauma or inflammatory disease would also support an inherited origin. In this series, bilaterality was more than five times as frequent in the group without dialyses as in the group with dialyses. A positive family history of retinal detachment was higher in the group without dialyses than in the group with dialyses, 3.1% compared with 1.5%.

Francois[25,26] stated that there "sometimes" is a "hereditary factor in the pathogenesis" and that it sometimes is transmitted as a "recessive, occasionally sex linked, but more often as an autosomal irregular dominant." He further stated that although inherited forms of retinal detachment were usually transmitted along with the genetic factors transmitting myopia, occasionally retinal detachment was transmitted independently of myopia. Although he presented several cases of dialyses with some evidence of familial occurrence, he did not report any conclusive evidence to support a specific inherited pattern, and he therefore concluded that most dialyses resulted from a "congenital" retinal cyst.

Waardenburg et al[48] summarized all the hereditary cases of retinal detachment previously reported and concluded that the majority of these were inherited in an "irregularly-dominant" pattern and the minority in a "recessive pattern." He also emphasized that these cases are not always associated with myopia and that eyes with dialyses possibly had some type of "congenital inferiority," which he presumed was due to the differential growth rate of the inferior portion of the optic cup resulting in thinning of the anterior temporal retina. He believed that this quadrant of the peripheral retina is phylogenetically younger and therefore "less stable and prone to variations and anomalies."

Although Levy[27] is frequently cited as reporting cases to support a sex-linked mode of inheritance for retinal dialyses, he actually presented only two pedigrees. The first contained three affected males in two generations. One family member had a unilateral lower temporal dialysis, and a nephew had a bilateral dialysis. The propositus's brother had an old retinal detachment of undetermined cause in the one eye, and a dialysis was suspected but could not be visualized. The other pedigree Levy reported as having a dialysis was consistent with a sex-linked recessive mode of inheritance, but a review of his description and illustrations indicated that this undoubtedly was a case of congenital retinoschisis.

Richardson[28] claimed that dialyses developed from progression of juvenile retinoschisis, which ordinarily has a sex-linked inheritance pattern, yet in the four patients he presented to support his hypothesis, there were no other affected family members. Leffertstra[18] reported a 20% incidence of bilaterality, but only four (2%) of his 200 patients with dialysis had any other family members with detachment. In two of these, only two siblings had dialyses, and in the other two families only one parent and one child were affected. Verdaguer[15,49] examined the family members of 30 patients with a nontraumatic dialysis, and noted that 33% of the families had one or more other members with a dialysis. One of these families had monozygotic twins with symmetric unilateral dialyses. Since the incidence of dialysis in these families was 20 times higher than in the normal population of males 9 to 20 years of age, he concluded that there was an autosomal recessive mode of inheritance. However, the absence of involvement in more than one generation makes this statment unsupported. Rodriguez[33] reported an incidence of posterior dialysis in 13.7% of his patients with retinal detachment, and in 30% of these there were bilateral involvement. Because the incidence of bilaterality was the same in those patients with and without a history of trauma and since bilateral trauma can rarely be documented, he concluded that trauma is not important in the development of dialyses. He hypothesized that a genetic factor must be present.

Even in our patients with bilateral dialyses, we found none of the obvious dysmorphic features in either the patients or their family members to indicate any evidence of the known genetic syndromes. In the nine families we examined extensively, only two families had more than one involved member. In one family there was a symmetric dialysis in a sibling and in the other, there was a dialysis in a father and in his son. Chromsomal studies, physical examinations, and biochemical urine examinations have been uniformly normal in the patients and in the family members we have examined. Perhaps we have not examined a large enough sample of families, but our data to date show no evidence of any of the known genetic abnormalities or any specific inherited pattern.

In summary, a review of the literature reveals that there are only a few scattered case reports of dialyses in siblings and only three case reports of dialyses in more than one generation.[15,18,27] We have shown in this series that the incidence of bilaterality and a family history of retinal detachment are significantly more common in nondialysis patients than in dialysis patients. We must therefore conclude that a dialysis or even the predisposition to develop a dialysis is rarely inherited, and we must look for other causes in the majority of cases.

NONHEREDITARY THEORIES OF PATHOGENESIS

From our review of the literature, the various etiologic theories that have been proposed can be conveniently separated into five major groups: (1) progression of microcystoid degeneration or retinoschisis, (2) progressive enlargement of an intraretinal macrocyst producing a mechanical dialysis, (3) a congenital inherent weakness of the extreme retinal periphery, especially in the lower temporal quadrant, produced by a differential rate of growth of the peripheral retina during embryologic development, (4) trauma of various types, and (5) heredity.

Numerous articles in the literature claim to show that nontraumatic posterior dialyses are caused by an enlargement of one or more intraretinal cysts, by progression of microcystoid degeneration, or by retinoschisis.[2,8,28,32,43,44] None of these contain reports of any pathologic material to support these theories, nor do these reports present any clear explanation as to how a retinoschisis could result in a tear in both the internal and external layers without visible separation of the peripheral detached retina into two separate layers. Also, retinoschisis is usually bilateral and retinoschisis was rare in our series. Our data clearly indicate that intraretinal macrocysts that occur frequently in eyes with dialyses are degenerative in nature and occur in long-standing retinal detachment of any type, and they therefore are not related to the production of the dialysis. In addition, there have been no reports similar to the single case report by Duke-Elder,[43] in which he observed the enlargement of an intraretinal cyst that eventually produced a dialysis. In my clinical experience I have been unable to find a solitary intraretinal cyst in the retina in the absence of a retinal detachment.

Numerous authors[2,5,8,32,34,48] have emphasized the normal histologic feature of thinning of the peripheral retina, especially in the lower temporal quadrant, This is assumed to be related to the differential growth rate of the optic cup during embryologic development. This lower temporal quadrant is also the least protected by the bony orbit and therefore more frequently subjected to trauma, both major and minor. There are no reports, however, of any statistical data that would support the hypothesis that minor trauma is responsible for the production of a lower temporal dialysis.

As mentioned before, a significantly higher percentage of patients in our series with dialyses had either objective signs or history of major ocular trauma than patients with other types of retinal detachment, and in addition there is firm experimental evidence in animals that a contusion injury to the center of the cornea will produce an anterior dialysis of the ciliary epithelium, frequently in the upper nasal quadrant.[12] These studies also showed that direct trauma to the region of the ora can produce a typical posterior dialysis of the retina, although much less frequently. Recently, studies have shown that perforating injuries in primates will produce a typical anterior dialysis.[13] Further, there have been prospective studies of human beings who experienced contusion injuries, in whom dialyses developed subsequently at a rate of 3% to 19%.[38-40]

Our data give strong statistical evidence that trauma is the major cause of anterior dialyses but a much less frequent cause of posterior dialyses. Our data implicated major trauma as a causative factor in 82% of anterior dialyses, 14% of posterior dialyses, and only 5% of eyes with retinal detachment caused by other tears.

Scott[51] believes that there is a subtle type of primary degeneration of the retina and vitreous that accounts for the nontraumatic posterior dialyses. I do not believe that we have any clinical evidence to support his theories, and from his description, I believe he is describing microcystoid degeneration, which we observed frequently in the detached portion of the retina of our patients who had long-standing dialyses.

The high incidence of dialyses and the high incidence of bilateral dialyses that have been noted in American Indians,[37] Colombian Indians,[33] and Chinese (Chang, oral communication) would indicate that some ethnic factors may account for the production of dialyses. It would be most unusual for a common environmental factor to produce the high incidence of dialyses in these three ethnic groups, which are geographically separated by such great distance. However, American Indians, South American Indians, and Orientals do apparently have common racial ancestry.

SUMMARY AND CONCLUSION

This statistical clinical study of 523 eyes with retinal dialysis treated surgically has clearly demonstrated that retinal detachment produced by this specific type of tear has numerous characteristics that are significantly different from retinal detachment produced by other types of tears. Our statistical tests have indicated, at the 0.005 level, that in the dialysis group there is a younger age of onset and an increased incidence of men, blacks, hyperopia, and emmetropia, and a decreased incidence of myopia, aphakia, peripheral retinal degeneration, visible vitreous membranes, fixed retinal folds, a family history of retinal detachment, and bilaterality. It was found that there is a larger precentage of dialysis patients without any symptoms and, further, that dialysis patients have a longer duration of detachment at the time of diagnosis than patients without dialyses. In spite of the prolonged duration, eyes with dialysis have fewer quadrants de-

tached. Related to the prolonged duration in dialysis patients, there is a significantly increased incidence of intraretinal cysts, demarcation lines, cystoid macular degeneration, macular detachment, and a diminished percentage of patients with a final visual acuity 20/50 or greater. We have concluded that the prolonged duration in dialysis patients occurs primarily because of the absence of a posterior vitreous detachment.

Direct ocular trauma, as evidenced by visible signs or a verified history, is significantly more prevalent in dialysis patients. In the 37% of dialysis patients with evidence of trauma, there was a decrease in the rate of anatomic reattachment, but this was not found to be statistically significant. Patients without dialysis of any type required significantly fewer operations to obtain reattachment than other patients. The traumatic dialyses occur statistically more frequently anterior to the ora and are associated with an increased incidence of vitreous membranes and vitreous hemorrhage. The age of onset in the traumatic group is lower and the incidence of men and blacks is higher than in the nontraumatic group, and there is an increased incidence of detachment of the ciliary epithelium.

In 63% of the dialysis eyes there was no clear-cut evidence of ocular trauma. A small proportion (17%) of this group had a variety of known causes to account for the dialysis, and most of these were associated with vitreous membranes and a dialysis located anterior to the ora in the ciliary epithelium. In the great majority of patients (91%) without evidence of trauma, the dialysis was located posterior to the ora, most frequently in the lower temporal quadrant and the next most frequently in the upper temporal quadrant. We did not discover any consistent features in this group to permit determination of a specific cause, hereditable or otherwise. However, in almost every other parameter measured, this group closely corresponded statistically with the group of patients with a dialysis resulting from proved trauma; we have therefore concluded that trauma, too minor to produce permanent signs and perhaps even unremembered, may indeed be responsible in at least a large proportion of this group.

There is evidence of a polygenic transmission in a small percentage of patients with a nontraumatic retinal dialysis. However, both the rate of bilateral involvement and the incidence of a positive family history of retinal detachment are significantly lower in dialysis patients than in nondialysis patients. We have speculated that minor trauma or some environmental insult associated with the as yet undefined hereditable factors will cause a dialysis in at least some of the patients we have presently classified as having an "idiopathic" dialysis.

Until other specific causes for retinal dialyses have been identified, I propose that it would be most useful for ophthalmologists to classify each patient with a dialysis into one of the two major anatomic groups, anterior (ciliary epithelium) or posterior (retinal). Anterior dialyses should be further subdivided into one of four main etiologic groups: (1) those secondary to contusion trauma, (2) those secondary to penetrating trauma, (3) those secondary to contraction of vitreous membranes following chorioretinal inflammatory disease or systemic vascular disease, and (4) those secondary to vitreous loss following intraocular surgical treatment. The posterior dialyses involving the retina should be classified into two groups: (1) those secondary to verified trauma and (2) those of undetermined or "idiopathic" origin. Table XXIV indicates the percentage of patients we have classified, in our series, into each of these major groups.

This classification would appear to accurately reflect our current knowledge regarding the diverse pathogenesis of this type of retinal tear, and it should prevent further confusion in the literature and assist in future research to uncover the etiologic factors of that last group, comprising 57% of all dialyses, presently classified as "idiopathic."

It is discouraging and disconcerting that the detailed clinical and sophisticated statistical studies performed on the largest group of eyes with a retinal detachment produced by a dialysis ever reported has not enabled us to determine the pathogenesis in the large group of "idiopathic" dialyses. However, this study has more clearly described and documented the characteristics and the natural history of retinal detachment caused by dialysis, and it has firmly established that the pathogenesis is different from the vitreoretinal degenerations that account for 90% of all rhegmatogenous retinal detachments.

We hope this report will stimulate further research to determine the pathogenesis of idiopathic dialyses. Biochemical and cytologic examination of the composition of the subretinal fluid from patients with dialyses and other types of retinal tears may be informative. Detailed clinical and statistical evaluation of various ethnic and geographically located groups with retinal detachment, especially ophthalmoscopic examination of family members, should provide valuable information. Detailed ophthalmoscopic surveys of young age groups would provide us with the incidence of dialyses in the normal population and might reveal evidence of environmental factors not yet discovered. We plan to contact all the patients with nontraumatic dialyses in this study periodically so that their children, and eventually their grandchildren, can be examined. This should eventually enable an accurate determination of the role of heredity.

In the absence of pathologic material, microscopic and histochemical studies of the peripheral retina and ciliary epithelium, with special reference to the ultrastructure of the vitreous base and its attachment to the retina and ciliary epithelium, should be performed both on animal and eye-bank eyes to help determine the possible mechanism for the production of a posterior retinal dialysis.

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