1983

Intracapsular hip fracture : a clinical review

Alan Mark Reznik
Yale University

INTRACAPSULAR HIP FRACTURE: A CLINICAL REVIEW

Alan Mark Reznik

1983

Permission for photocopying or microfilming of "Intracapsular Hip Fractures: A Clinical Review
(title of thesis)
"

for the purpose of individual scholarly consultation or reference is hereby granted by the author. This permission is not to be interpreted as affecting publication of this work, or otherwise placing it in the public domain, and the author reserves all rights of ownership guaranteed under common law protection of unpublished manuscripts.

Alan Berk
(Signature of author)

Alan Berk
(Printed name)

2/11/83
(Date)

Intracapsular Hip Fracture: A Clinical Review

by

Alan Mark Reznik

A thesis
Submitted to the Yale University
School of Medicine
in partial fulfillment of the
requirements for the degree of
Doctor of Medicine

**

New Haven, Connecticut

March 1, 1983

Dedicated to my parents and my two sisters Beth and Renee.

I would like to acknowledge my advisor Ulrich H. Weil for his time and vast experience which proved to be invaluable throughout this project. I would like to thank the Orthopaedic Surgeons in New Haven who willingly gave their permission for this study. In addition a very special thanks to my fiancee Elizabeth S. Kaye for her help in preparing this manuscript.

Alan M. Reznik

I hereby declare that I am the sole author of this thesis. I authorize the Yale University to lend this thesis to other institutions or individuals for the purpose of scholarly research.

Alan Mark Reznik

The Yale University requires the signatures of all persons using or photocopying this thesis. Please sign below, and give address and date.

Rachel J Parke, Medical Library 10/8/2003

ABSTRACT

Sixty seven cases of intracapsular hip fractures treated at the Hospital of Saint Raphael in New Haven, Connecticut, during a twelve month period starting in September, 1979 were reviewed. Information pertaining to age, sex, medical history, cause of injury, hospital course (i.e., length of stay, number of days prior to treatment, length of physical therapy, level of activity at the time of discharge, etc.), type of treatment given, complications and mortality of these patients are presented and discussed. In order to evaluate the level of activity obtained by each patient, a scale ranging from one (non-ambulatory) to six (fully independent) was devised. The correlations between mortality and factors such as age, treatment choice, the diagnosis of organic brain syndrome, and the patients' level of activity prior to discharge were examined.

At the end of the study period, in December, 1982, the patient's level of activity was re-evaluated and comparisons of this level to factors such as age, treatment used, hospital course, activity levels at time of discharge as well as disposition were made in an effort to elucidate factors influencing outcome.

Programs from the Statistical Package for the Social Sciences (S.P.S.S.) and programs written by the author at Yale University's computer center were utilized to evaluate the raw data. Statistical significance of the results presented here were determined using standard statistical menthods (i.e Chi Squared and the Student T Test).

The mortality rates in the patient population have been compared to the mortality rates found in the general population, matched for age and sex, reported in the life tables for the United States. The statistical evaluation of these comparisons are given as well.

In intracapsular hip fractures long term results of treatment by Austin-Moore type prosthesis have been shown to be worse than treatment by internal fixation with respect to mortality and level of activity. Early surgery, early ambulation and early physical therapy have been correlated with better results. During the study period (over two years) the amount of improvement in level of activity after discharge has been shown to be minimal.

CONTENTS

Chapter I

INTRODUCTION

Intracapsular hip fractures have been the topic of a large volume of orthopaedic literature (85). They have been called the "Unsolved Fracture" with respect to their treatment in a classic article by Speed (73). Hip fractures are common in the aged and a high percentage of patients with these fractures become dependent on institutional care for the rest of their lives (3). The national short term treatment cost of this fracture has been estimated as high as one billion dollars per year (58). Optimal outcome is complicated by the fact that patients have underlying medical conditions that affect their treatment and a team approach in their care has been therefore advocated (10). In addition, avascular necrosis, malunion, nonunion and an increased mortality rate have been associated with this fracture (1, 2, 4, 5, 12, 30, 49, 60 and 81). The purpose of this paper is to review the results of treatment of intracapsular hip fractures in a community hospital in New Haven, Connecticut, by evaluating treatment choices, complications, and other factors with respect to outcome. The intention of this study is to elucidate factors that may or may not be helpful in predicting long term outcome.

Chapter II

REVIEW OF LITERATURE

2.1 HISTORICAL PERSPECTIVE

The first observation of femoral neck fractures is ascribed to Ambroise Paré (1510-1590) (2). However, it wasn't until Sir Astley Cooper wrote his treatise on dislocations and fractures of the joints (1823) (15) that a more scientific approach to these fractures began to take shape. In that study he distinguished between intra- and extra-capsular hip fractures. He also realized that intracapsular fractures did not heal readily because of the poor blood supply of the proximal fragment and that this insufficiency could lead to avascular necrosis. Gross stated (1859) (32) that proper apposition of the bone fragments was essential for bone union. In 1860, B. von Langenbeck attempted to promote healing of these fractures by using internal fixation. He was able to stablilize the head of the femur but the patient died of an overwhelming infection (42). Eighteen years later, F. Konig (41) met with success using a steel pin. The fracture united and the patient did well.

At that time, evidence collected from autopsy specimens indicated that hip fractures could heal. Hamilton (1869) reiterated that treatment "ought to be directed to the retention of bone in place, by suitable mechanical means for a length of time sufficient to insure bony union..." (33).

In 1881, Senn showed that pinning the fracture with a bone or ivory peg was superior to casting (67). Later, Nicolaysen reported on patients treated with both cast and pins and claimed that this combination was better than either treatment alone (57). However, in the late nineteenth and early twentieth century, casting patients with the involved lower limb in internal rotation, abduction and extention was still stan-

dard therapy. R. Whitman was the foremost proponent of this technique (83). In 1938 Leadbetter (43) modified Whitman's reduction maneuver. It is still used today (23).

In 1895, a significant advance in treating all fractures was made when Roentgen discovered that "X-rays" could penetrate skin and outline bone contours. From then on it was possible to classify hip fracture types by noninvasive means and to assess reduction and fracture healing (74).

At the turn of the century, new modalities of internal fixation were introduced. For example, Davis recommended the use of wood screws (17). However, it wasn't until 1931 that the standard technique of a triflange nail was first published by Smith-Petersen (70).

While studying the influence of mechanical forces on bone, osteogenesis and fracture healing, in the 1920's Martin, W. Müller, Walter, and Willich (47, 54, 82 and 84) observed that abnormal mechanical stress caused a deleterious effect on normal bone. Their experiments proved that normal bone, new bone formation, and in particular callus formation was affected by stress. Pauwels, in his revolutionary paper "Fracture of the Femoral Neck: A Mechanical Problem" written in 1935 (59) applied these findings and additional anatomical studies to develop a logical approach to the fixation of these fractures. He showed that placing the fixating device at an angle of 150 degrees to the femoral shaft increased the compressive force while reducing the "effective shearing force". His analytical studies had a great influence on modern thinking about the treatment of intracapsular fractures and his conclusions were confirmed by many other authors (Frankel, V. H. (25), Inman, V. T. (38),

Rydell (64) and Tronzo, R. G. (78)). A system of classification was developed by Pauwels and later by Garden, (1961) (59, 28, 30, 31) to specify the biomechanical properties correlated with a particular fracture type .

Other efforts to improve the fixation of the femoral head included Moore's use of multiple pins in 1934 (51), Knowles work in 1936 (40) and Deyerle's concept in 1959 (18). Deyerle also showed that the system of multiple pins had a large biomechanical advantage over single nail fixation (19). Lateral shaft fixation remained a problem until 1937 when Thorton reported on a design of a side plate for attachment to the Smith-Petersen nail (76). It was first used to treat introchanteric fractures and later for intracapsular fractures (66).

Godoy-Moreira in 1940 (53) reintroduced the concept of Davis (17) by using a "stud bolt screw" to repair femoral neck fractures. He reported a 97 per cent union rate using this technique.

Charnley et al. combined the screw concept with the sliding plate design and added a spring for active compression in 1957, creating the so called "compression screw" (13). Modern examples of the "compression screw" are the Richards (77) and the Yale (72) nails.

The telescoping nail was developed in the 1940's by Briggs (6). It had two important features: First, it had a friction device that caused the nail (Smith-Petersen) to slide in a sleeve against a given force and second, it was keyed to prevent rotation. The Pugh was inspired by Briggs and used his concept to design a similar device (24). He reported on this "self adjusting nail plate" which had the same features as the telescoping nail mentioned in 1955 (63). Massie published data on

his telescoping triflanged nail for treatment of femoral neck fractures in 1958 (48).

Posterior cortical comminution of a femoral neck fracture had been associated with a poor result (nonunion) by Garden (29) and others (22, 39, 50, 65). A suggested treatment was to remove an anterior portion of bone to compensate for the space left from the cortical bone defect posteriorly (65). Another approach was proposed by Doyen and Judet (22) and Judet (39). They used a muscle pedicle graft at the fracture site to obtain a high union rate (90 per cent by Meyers et al. (50)).

When the fracture is markly comminuted or displaced, prosthetic replacement has been advocated (34, 46, 75) and if the joint is degenerated, primary total hip replacement has been used (69). These treatments modalities are represented by the Austin-Moore prosthesis and the Charnley total hip joint prosthesis (8,35).

In summary, over the last 400 years three major concepts for the treatment of intracapsular hip fractures have come into use. They are conservative therapy (bedrest, traction and casting), pinning or nailing (rigid nail, telescoping nail, compression screw, multiple pins as well as nail or pins along with a muscle pedicle graft), and prosthetic replacement (hemi- and total arthroplasties).

2.2 RESULTS REPORTED IN THE LITERATURE

In the orthopaedic literature there have been many reports on individual techniques for treatment of intracapsular hip fractures for each of the three treatment concepts outlined in the previous section.

Crawford (16) reported on fifty-five impacted femoral neck fractures which were treated conservatively. In his patient population forty-nine of the fifty-five (89 per cent) fractures went on to union. Pierce and Powell (62) reported on Anderson's Well Leg Traction in patients with medical conditions preventing surgery, of his fifteen patients ten survived and nine (90 per cent of those who survived) went on to heal their fracture.

Sherk et al. (68) in their series on senile patients reported a 45 per cent mortality rate for patients with intracapsular fractures treated surgically as compared to 60 per cent if treatment was conservative.

Massie (49) reported on 267 cases of femoral neck fractures treated with a his telescoping nail. He found that in sixty-six undisplaced fractures there was a 20 per cent incidence of avascular necrosis. In the 201 displaced fractures the incidence of avascular nercrosis was 33 per cent and nonunion occurred in less than 5 per cent (only nine nonunions of the 201 displaced fractures). He reported other complications as well. They were, nail cut out (ten), infection (twelve), nail advancement into the acetabulum (ten), nail collapse (fifteen), and nail breakage (six). Malkin and Frankenburg (45) reported on eighty three intracapsular hip fractures treated with the Pugh nail. Fifty of their patients had an uncomplicated course (types of complications for this group were not reported). A series by Martens et al. (46) on multiple

pinning (using five to eight Knowles pins) showed that only forty-two of the sixty-one patients had achieved union (67 per cent). The factor most frequently correlated with the failure to achieve union was pin migration during the first few post operative months. Deyerle (18, 19, 20) using his own technique (multiple pins) found only a 9 per cent rate of avascular necrosis and a 1.8 per cent rate of nonunion. The use of a muscle pedicle bone graft as described by Doyen and Judet (22) and Judet (39) has been reported on by Meyers et al. (50) in 181 cases with posterior comminution in intracapsular fractures. In the series by Meyers et al. 90 per cent achieved union rate in less than six months and in 4.9 per cent avascular necrosis was observed.

Hinckey and Day (35) reported on 294 cases using an Austin-Moore Vitallium prosthesis (52) as a primary treatment for fresh hip fractures. In their series there were twelve infections, four hematomas, one dislocation, two femoral fractures and twenty-eight patients with pain in the replaced hip. They reported a 30 per cent mortality in the first year and 50 per cent after four to eight years of follow up. Hunter (37) studied 186 patients with femoral neck fractures, ninety-six of which were treated with prosthetic replacement within the first twenty-four hours. He showed the prosthesis group to have a higher mortality rate than the internal fixation group (41 per cent as compared to 15 per cent). Hunter also studied functional outcome. He reported eighteen of forty-six patients with "good" results in the prosthesis group and thirty-two of forty-five patients with "good" results in the internal fixation group. He defined a "good" result as having "minimal pain," "walks over 100 yards unaided with one stick" and "performs household

duties." From these data he recommended that prosthesis treatment should be reserved for patients where adequate reduction is impossible. Coates and Armour (14) and later Sim and Staufer (69) reported on primary total hip replacement as treatment for fractures of the femoral neck. In Coates and Armour's series of eighty-six patients with an average follow up of seventeen months (range six to thirty-six months), twenty-five died (29 per cent), six were lost to follow up, 7 per cent had infections and 13 per cent suffered "major decline" in ability to walk. In Sim's series on 112 patients, eighty-five with greater than one year follow up, only thirteen patients ability to walk improved while thirty-three patients ability to walk declined.

2.3 EPIDEMIOLOGY AND PREDICTION OF RESULTS

In published epidemiologic studies, hip fractures are noted to occur largely in people of advanced age and females (9, 10, 11, 26, 27, 44, 58). The median age has been reported to be as high as seventy-eight years (27) for men and women in the United States and as low as fifty-six years for men in Johannesburg (71). From data published by Lewinnek et al. (44) the incidence of hip fractures in blacks can be calculated to be as high as one-fourth or as low as one-nineteenth the incidence of hip fractures in whites. Osteoporosis has been associated with increased fracture rates (44, 58).

In an attempt to correlate the incidence of diabetes, rheumatoid arthritis, thyrotoxicosis and hyperparathyroidism in patients with hip fractures (27), only thyrotoxicosis had an increased prevalence rate that was shown to be statistically significant.

Ceder et al. (11) used what he called "cluster analysis" to show different factors important in prediction of recovery. In his study the patients' function at discharge was most closely related to their ability to ambulate again two weeks postoperatively, followed by the factors "living with someone" at the time of fracture, and medical condition. In the same study, at one year "visiting someone prior to the fracture" and age were the most predictive factors.

Increased incidence of other fractures have been associated with hip fractures. In a paper by Gallagher et al. (26) 68 per cent of the women and 59 per cent of the men had some other fracture prior to the hip fracture. In a later paper (27), he showed a statistically significant increase in the incidence of Colles fractures during the ten years prior to the hip fracture; he expected fifty-five Colles fractures in his patient population and found seventy-three.

2.4 MOST RECENT MAJOR CLINICAL STUDIES

There have been several papers in the last few decades that report on the follow up of large numbers of patients (greater than 100) for long periods of time (more than two years). These include studies by Banks (2), Fielding et al. (23), Garden (30), Massie (49) and Barnes et al. (3).

Banks (2) in his study of 301 femoral neck fractures found that of 213 displaced fractures 72.4 per cent healed: impacted fractures united in 96.6 per cent of the cases, comminution reduced the rate of healing

to 33 per cent and avascular necrosis occured in one-fourth of the cases. It is important to note that he believed that no weight bearing should be permitted until roentgenologic evidence of fracture healing had occurred.

Fielding et al. (23) in their series on 179 patients, found that in undisplaced fractures avascular necrosis occurred in 12.1 per cent and in 22.7 per cent of the displaced fractures. There were thirty-two nonunions (23.6 per cent). Their non-union rate with Smith-Petersen nails was 50 per cent as compared to 10 per cent for the Pugh nail.

Garden (30) treated 500 patients during a fifteen year period and found that 323 (64 per cent) fractures united, eighty-three (16.6 per cent) did not unite, sixty-nine (13.8 per cent) died prior to determination of result, eleven (2.2 per cent) were non-surgical candidates and fourteen (2.8 per cent) were lost to follow up. He also showed that his "alignment index" which is a comparison of the angle of the trabecular projection in the femoral neck on the roentgenograph with that of the medial cortex in two views (antero-posterior and lateral), correlated with the rate of union.

Massie (49) studied 267 patients treated with a triflanged telescoping nail using combined radioisotope and non-radioisotope techniques. He showed that devices with a side plate that allow for surgical impaction, i.e., three point fixation, has "successfully eliminated nonunion unassociated with avascular necrosis" as a complication. Avascular necrosis occurred in 22 per cent of his cases.

Barnes et al. (3) followed 1,503 patients for an average of three years. They showed that in Garden stage I and II all but a few frac-

tures united and in Garden stage III and IV, 67 per cent united. (Garden's stage I: the fracture is incomplete or impacted; stage II: the fracture is not displaced; stage III: the fracture is partially displaced; stage IV: the fracture is completely displaced (28).) He found avascular necrosis in 16 per cent of stage I and 26 per cent of stage III and IV patients. A delay in treatment of as much as one week did not seem to influence the outcome.

Chapter III

MATERIALS AND METHODS

3.1 INTRODUCTION

The collection of raw data for this project was divided into several different components. These components were selection of patients, review of hospital records, review of the death certificates of patients who died during the study, and follow up evaluation of the remaining living patients.

3.2 PERMISSION FOR STUDY

Permission prior to this study for using Hospital of Saint Raphael records was obtained from Ulrich Weil, M.D., my advisor, Alan Goodman, M.D., the Chairman of Orthopaedic Surgery at Hospital of Saint Raphael, and L. Trifari, M.D., the Director of Medical Records at Hospital of Saint Raphael. Permission for follow up of the patients was requested from each patient's physician before patients were contacted. Finally, permission to examine records of patients for cause and date of death was procured from the Bureau of Vital Statistics in each of the individual municipalities.

3.3 CHOOSING THE DATA BASE

The list of patients included in this study was prepared by reviewing the records at the Hospital of Saint Raphael in New Haven, Connecticut. This is a 482 bed community hospital with a stong teaching affiliation with the Yale School of Medicine.

The Hospital uses an I.B.M. 4341 main frame computer for maintaining records of each patient for each admission. It contains files that include the patient's primary diagnosis, secondary diagnoses, procedures done on that admission as well as other data. These data are encoded according to the ICD-9-CM (International Classifications of Diseases, ninth Revision, Clinical Modification) set of diagnostic codes (80). The system allows retrieval of patients by coded diagnosis instead of by name.

Table 1 shows a partial list of the ICD section on fractures of the lower limb, pertaining to the neck of the femur (ICD-9-CM code 820). It should be noted that Per- and Subtrochanteric fractures are also included under this heading. From this system of classification I immediately eliminated several subcodes due to the fact that this study concerns only intracapsular fractures of the femur in adults. The sections dropped were 820.01 Epiphysis (separation) (upper) closed, the section on Pertrochanteric, closed (820.2), and Pertrochanteric, open (820.3). As there were no patients with open intracapsular fractures in this study, section 820.1 (Transcervical fracture, open) and 820.9 (Unspecified Part of the Neck of the Femur, open) were also eliminated. The one remaining section (820.8) refers to unspecified parts of the neck of the femur, therefore, further scrutiny was required once the charts were obtained

to assure that the patients met the criteria outlined above. The codes used in the study are indicated by an asterisk in table 1 .

TABLE 1

The ICD-9-CM Code Pertaining to the Hip

Fracture of the Lower Limb (820-829)

820 Fracture of Neck of Femur

- 820.0 Transcervical Fracture, Closed *
  - 820.00 Intracapsular section, unspecified *
  - 820.01 Epiphysis (separation) (upper)
  - 820.02 Midcervical section *
  - 820.03 Base of Neck *
  - 820.09 Other *
- 820.1 Transcervical Fracture, Open
  - 820.10 Intracapsular section, unspecified
  - 820.11 Epiphysis (separation) (upper)
  - 820.12 Midcervical section
  - 820.13 Base of Neck
  - 820.19 Other
- 820.2 Pertrochanteric Fracture, Closed
  - 820.20 Trochanteric section, unspecified
  - 820.21 Intertrochanteric section
  - 820.22 Subtrochanteric section
- 820.3 Pertrochanteric Fracture, Open
  - 820.30 Trochanteric section, unspecified
  - 820.31 Intertrochanteric section
  - 820.32 Subtrochanteric section
- 820.8 Unspecified Part of the Neck of the Femur, Closed *
- 820.9 Unspecified Part of the Neck of the Femur, Open

---

* Codes used in patient selection.

In selecting the study period it was necessary to consider late complications of hip fractures. One of the late complications of any fracture is nonunion, and published data indicate that this complication is usually detected within one year (49). In the same reference 84 per cent of fractures united within the first six months. As already mentioned it is also well known that avascular necrosis is a late complication of injury of the proximal femur (85). Banks stated in 1962 (2) that most cases of avascular necrosis become clinically apparent within one to two years of the initial injury.

In order to insure that at least two years of follow up would be possible, patients admitted to the hospital during the twelve month period starting in September, 1979 were selected for this study and the study was terminated in December, 1982.

3.4 AQUISITION OF THE RAW DATA

Once the patients were selected their entire hospital record was reviewed. Using the format shown in figure 1 the patients past history and hospital course (including procedure, complications, and progress made during physical therapy) was summarized. The hospital summary sheet (figure 1) constructed for this study is similar to the abstract sheet used by Gallager in his study on epidemiology of hip fractures (26). Limited demographic data (i.e., physician's name, patient's address and phone number) were recorded to aid in the follow up.

Hospital Record #

Date of Birth: Age:

Sex: Race:

Physician (for follow up purposes):

Date of Admission:
Date of Discharge:
Primary Diagnosis:
Primary Procedure:
Date of Procedure:
Other Procedures and Dates:

Past Medical History:

Medications:

Past Surgical History:

Surgery:

Operative Complications:

Post Operative Complications:

First day out of Bed: First day Physical Therapy:

Course of Physical Therapy:

Highest level of Activity:

Discharged to:

If died during hospitalization, cause of death:

Address for follow up:

Phone number for follow up:

Figure 1: Record of Hospital Stay

---

1) Is the patient living at home?

   a. If not, at Convalescent Home or other such facility?

   b. If at Convalescent Home, type of care required?

2) Level of Activity:

   a. Independent with aids, without symptoms:
      If not, answer below.

      1. Maximum walking distance without pain?

      2. If assistance is required for ambulating, what type?

      3. If patient has symptoms, are pain medications
         needed and which ones?

   b. If aid is required (i.e., walker, cane, etc.),
      which and in what way?

   c. The level of activity determined from the above information:

3) Changes in health since fracture of hip?

4) Hospitalizations since hip fracture:

5) Complications or changes due to hip fracture:

   a. Other procedures at same hospital:
      (since inital admission)

   b. Fractures or other bone diseases:

   c. Xrays taken since fracture and result if known:

Figure 2: Telephone Questionaire For Patient Follow up

The patient list was then broken down by the municipality in which each patient resided. The records of each Town's Office of Vital Statistics were reviewed to determine if any patients had died since their initial hospitalization. When a patient's death certificate was located, the cause, date, and any secondary diagnosis indicated at the time of death was recorded.

The remaining patients were contacted directly by phone. They were questioned using standard telephone survey techniques (21). The questions included inquiries for location of the patient, level of activity, symptoms in regard to the injured hip, changes in overall health, hospitalizations since the fracture and complications.

The information gathered was entered in the form shown in figure 2. When a patient lived in a convalescent home or was not capable to answer questions personally the questions were answered by the primary caregiver or the nurse in charge of that patient.

The level of activity determined from the hospital chart and the level of activity at the time of follow up was then divided on a numerical scale from zero (0) to six (6). Total bed rest was rated as an activity level of zero (0) and a level of six (6) indicated that the patient was fully independent on level ground and capable of using stairs freely. These levels are described fully in table 2. This system greatly facilitated the data analysis.

TABLE 2

The Level of Activity Grading System

Level of Activity

0 - Bed rest; requires lifting to be moved or so called "Total Care". "Total Care" is a nursing term which indicates patient needs feeding, bathing and is often incontinent.

1 - Out of bed with assistance, can walk a few feet with assistance, patient capable of "transfer". "Transfer" is a term used by Physical Therapists to denote changes in position for example, bed to chair, chair to standing, in and out of a bath tub, in and out of a wheel chair, etc..

2 - Same as Level 1 and can walk with a walker on level ground for a distance of less than fifty feet, usually requiring the assistance of another person.

3 - Same as level 2, but walking distance greater than or equal to fifty feet. However, the patient is not independent and does at times require help from another person.

4 - Independent on level ground with an aid. An aid may be crutches, walker, or cane.

5 - Independent on level ground with an aid as well as on stairs with an aid. This includes patients that are independent on level ground without an aid, however they require a cane or other aid on stairs.

6 - Fully independent without aids on both level ground and stairs.

3.5 THE USE OF LIFE TABLES AND STATISTICAL EVALUATIONS

To compare the data collected on patient mortality to published life tables, a group matched as to age and sex was chosen. The United States Department of Health and Human Services Actuarial Study Number Eighty-seven (79) for the year corresponding to the start of the study provided the life tables for this purpose.

Since each patient was in the study for a different time period, i.e., the time of fracture until December 1982, it was necessary to account for this difference when predicting patient mortality from the life tables. The predicted value was calculated based on the sum of the number of people who died during each year corresponding to each one of the years that the patient was in the study. When the last year in the study was fractional, that fraction of deaths in that year was added to the previous total. This total was then divided by the general population alive at the beginning of the first year that a patient was in the study. The resultant fraction indicated the chances of that particular person to die during the course of the study if he or she was a member of the general population as it appears in the actuarial life tables for this country. The addition of these fractions yielded a predicted number of deaths for the particular subpopulation of the patients being studied. The predicted mortality rate is equal to the predicted number of deaths divided by the number of patients in the group initially selected.

Statistic evaluation of this value utilized the assumption that the life table data fits a Poisson Distribution (Simeon P. Poisson, 1781-1840, Model of Outcomes (56)). By using this assumption, the var-

iance is equal to the mean, in this case the number of patients that expired. Therefore, the variance is equal to the predicted number of deaths. Since in a Poisson Distribution the standard error is equal to the square root of the variance, the standard error is equal to the square root of the number of deaths. Once knowing the standard error and the shape of the statistical distribution, P values can be determined and statistical statements can be made.

After collection of all statistical data, they were evaluated with two different computer systems. The major system used was Yale University Computer Center's IBM 4341 with programs in the Statistical Package for the Social Sciences (S.P.S.S.) (55), i.e., programs for chi squared and scattergrams. In addition, the author wrote programs for the IBM 4341 to do various statistical tests interactively (i.e., the program for the student T test shown in Appendix A). The other device used was the Hewlett Packard 32E programable calculator on which mean and standard deviation calculations were performed.

The formulae and statistical tables used were from several references (7, 36,61). The formulae used are to be found in Appendix B.

3.6 THE TABLES IN THIS PAPER

Throughout this paper, tables and charts summarize data on various subpopulations of the original study group. Most of these were made on Yale's IBM 4341. The process of sorting the patients into different subpopulations (i.e., by types of treatment, previous diagnosis, etc.)

was done by careful perusal of each patient record. This resulted in several master tables that contained summary data on each patient. These were then used to produce the data presented here.

Chapter IV

RESULTS

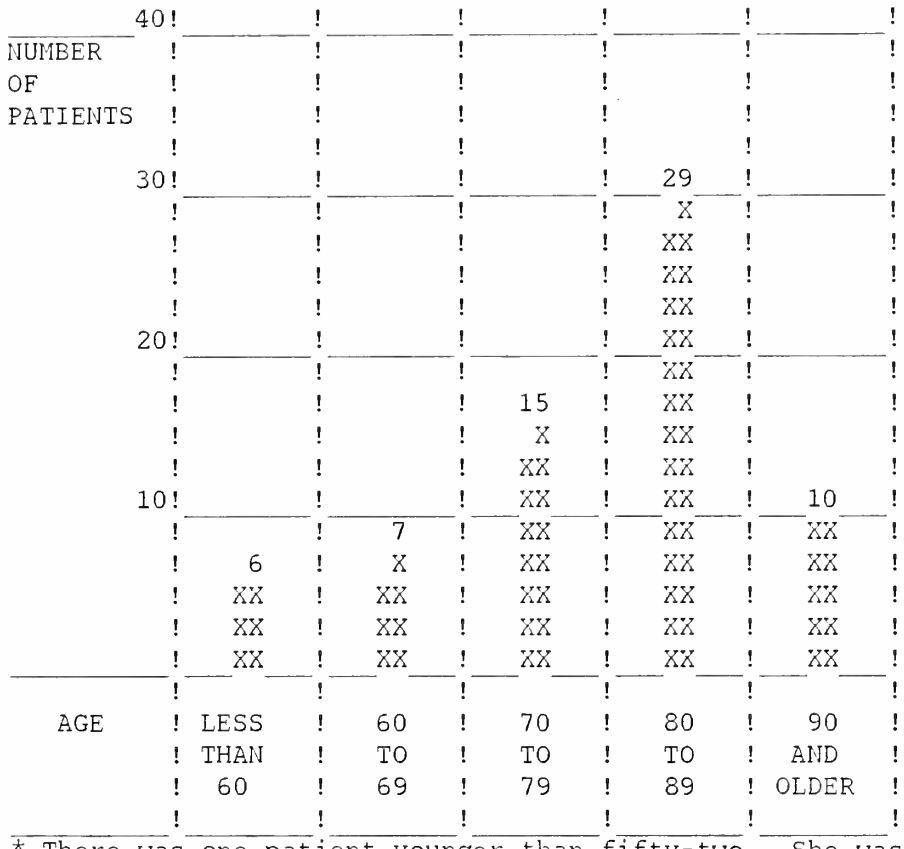
4.1 PATIENT POPULATION

The patients were selected as explained in the chapter on materials and methods. The major criteria were that at least two years of follow up would be feasible from the time of fracture and that the patients had an ICD-9-CM code that indicated fracture of the femoral neck as a primary diagnosis.

The two major criteria stated above generated ninety patient charts, but only sixty-seven patients had true intracapsular hip fractures. Twenty-three patients had to be excluded because of incorrectly coded fractures and fractures coded as "Unspecified part of the neck of the femur" that were not intracapsular fractures.

In the group used for the study there were forty-one females (73 per cent) and eighteen males (27 per cent). Their average age was 78.4 with a standard deviation of 11.9. There were six patients less than sixty years and ten patients over ninety years of age (see figure 3). Thirty-one cases were fractures of the right hip and thirty-six of the left hip.

Most of these patients carried other diagnoses as well as the primary diagnosis of hip fracture. Several had multiple underlying diseases. The seven most frequent were: arteriosclerosis (twenty-one), organic brain syndrome (seventeen), hypertension (fourteen), congestive heart failure (eleven), adult onset diabetes mellitus (nine), cerebrovascular accident (six) and arthritis (five). Many less common diagnoses are listed and tabulated in Table 3 .



* There was one patient younger than fifty-two. She was thirty-five at the time of the fracture.

Figure 3: Age Distribution of Patients with Intracapsular Hip Fractures

Seventeen patients (21 per cent) had been already admitted to a convalescent home prior to the hip fracture. It should be noted that five of the patients had a recent history of fracture of another bone.

TABLE 3

Secondary Diagnoses at Time of Hip Fracture

Diagnosis	Incidence
Abdominal Aneurysm	2
Adult Onset Diabetes Mellitus	9
Alcohol Abuse	4
Anemia	4
Arteriosclerosis	21
Arthritis	5
Atrial Fibrillation	4
Bradycardia	1
Brain Surgery	1
Cancer: Kidney (Benign)	1
Palate (Benign)	1
Parotid Gland (Benign)	1
Cavitating Lung Lesion	1
Cerebrovascular Accident	6
Cervical Spondylosis	1
Chonic Obstructive Pulmonary Disease	3
Congestive Heart Failure	11
Deafness	3
Depression, Chronic Severe	1
Fractures of other Bones	5
Glaucoma	3
Gout	1
Hypertension	14
Mitral Valve Prolapse	1
Multiple Myeloma	1
Myocardial Infarction	4
Organic Brain Syndrome	17
Parkinson's Disease	2
Peptic Ulcer	1
Pericardial Effusion	1
Psoriasis	1
Right Bundle Branch Block	1
Schizophrenia	1
Seizures	1
Upper Gastro-intestinal Bleeding	1

The cause of injury was not discernible in the majority of cases. In

sixty-three of the sixty-seven patients studied, a simple fall of unclear cause was the recorded event that precipitated the fracture. In two cases, ice skating accidents were blamed and in two other cases, motor vehicle accidents were responsible for the fracture.

Eight patients were lost to follow up during the course of the study. They are not included in the sections subsequent to the section on hospital course.

4.2 HOSPITAL COURSE

During a typical patient's hospital stay due to a hip fracture, there is a common therapy sequence which ultimately leads to discharge. This refers to timing of the initial procedure, the first post operative day out of bed, the first day on which physical therapy is instituted and a patient's achievement of an activity level prior to discharge. The approach I have taken to evaluate this information was to summarize these data on each patient and present it grouped by different factors (i.e., sex, age, or treatment choice).

As a basis of comparison, the average patient stayed in the hospital 17.4 (standard deviation of 7.4) days, was operated on close to the third day (average 2.7, standard deviation of 3.4) and achieved an activity level of 2.4 (standard deviation of 1.9). This was accompanied by the average patient getting out of bed on day 3.3 (standard deviation 2.2) (nine patients who were never permitted to get out of bed are not included) and starting physical therapy on day 4.9 (standard deviation

of 3.1). This does not include those fourteen patients who never had physical therapy during hospitalization. The average length of physical therapy was nine days (standard deviation of 6.9).

Interestingly, there was a great deal of variability in the data. The range in the length of hospital stay was from as little as three days, a case where the patient died intra-operatively, to as many as forty one days, where the patient had several medical problems that delayed surgery, as well as recovery. The total effort expended on physcal therapy varied from no therapy to twenty nine days of treatment and the resultant level of activity ranged from zero to six.

In table 4 the data are grouped by sex. From the averages and the standard deviations presented, there is little or no difference between men and women with regard to length of stay or level of activity on discharge. In other words, P in these cases is much greater than 0.1. In addition, in table 5 the means and standard deviations show that there is no statistical difference between the men and the women in this study with respect to delay prior to the surgical procedure, the timing of post-operative ambulation, the onset of physical therapy or the duration of such therapy.

In table 6 where the patients were grouped by treatment, differences in the subpopulations begin to become apparent. Patients that were treated by excising the femoral head and replacing it with an Austin-Moore prosthesis required a longer hospital stay than the other groups. The population requiring conservative treatment had the shortest hospi-

TABLE 4

Data On Total Population, Males and Females

POPULATION	#	%	AVERAGE AGE	AVERAGE HOSPITAL STAY	LEVEL OF ACTIVITY
TOTAL	67	100.0	78.4	17.4	2.4
(S.D.)			(11.9)	(7.4)	(1.9)
FEMALES	49	73.1	77.6	17.9	2.4
			(12.2)	(6.7)	(1.9)
MALES	18	26.9	80.7	16.0	2.4
			(11.2)	(9.5)	(2.0)

TABLE 5

Data on Hospital Stay by Total Population, Males and Females

POPULATION	DAYS PRIOR TO PROCEDURE	1ST DAY OUT OF BED	1ST DAY P.T.	# DAYS OF P.T.
TOTAL	2.1	3.3	4.9	9.0
(S.D.)	(3.4)	(2.2)	(3.1)	(6.9)
FEMALES	2.3	3.4	4.6	8.7
	(3.1)	(2.3)	(2.9)	(6.7)
MALES	3.7	3.1	5.8	9.9
	(4.6)	(1.8)	(3.4)	(7.6)

tal stay as well as the highest level of activity at the time of discharge. The level they achieved was four and as stated previously a level of four is equivalent to being independent on level ground with an aid (i.e., walker, crutches, etc.). Of particular interest is the group of patients treated by a hip nail. The Massie Nail patient group stayed

TABLE 6

Length of Hospital Stay and Level of Activity by Treatment Choice

POPULATION	#	%	AVERAGE AGE	AVERAGE HOSPITAL STAY	LEVEL OF ACTIVITY
TOTAL	67	100.0	78.4	17.4	2.4
(S.D.)			(11.9)	(7.4)	(1.9)
AUSTIN-MOORE	41	61.2	81.9	18.1	2.4
			(8.4)	(9.0)	(1.8)
MASSIE NAIL	12	17.9	70.8	14.3	3.6
			(16.6)	(4.3)	(1.6)
YALE NAIL	6	9.0	71.7	14.5	2.0
			(11.8)	(3.9)	(2.3)
CONSERVA-TIVE TX	4	6.0	67.8	11.5	4.0
			(11.8)	(1.9)	(1.0)
NON-SURG. CANDIDATE	2	3.0	90.5	8.5	0.0
			(9.2)	(7.8)	(0.0)
KNOWLES PINS	1	1.5	90	21	0.0
THOMSON PROSTHESIS	1	1.5	74	20	0.0

in the hospital a relatively short period of time (approximately fourteen days as compared to an overall mean stay of seventeen days) and left the hospital after obtaining a fairly good level of activity (3.6). Meanwhile, the Yale Nail group stayed about the same length of time, yet they did not achieve the same level of activity at the time of discharge, realizing a level of two. The level (two) achieved by this group has to be considered as poor. The patients who were considered to

TABLE 7

Length of Hospital Stay and Level of Activity by Treatment Group

POPULATION	#	%	AVERAGE AGE	AVERAGE HOSPITAL STAY	LEVEL OF ACTIVITY
TOTAL	67	100.0	78.4	17.4	2.4
(S.D.)			(11.9)	(7.4)	(1.9)
AUSTIN-MOORE	41	61.2	81.9	18.1	2.4
			(8.4)	(9.0)	(1.8)
NAIL OR PIN	19	28.4	72.1	14.7	2.9
			(15.0)	(4.2)	(1.9)
OTHER TREATMENT *	6	9.0	75.3	10.5	2.0
			(15.4)	(4.1)	(2.3)

NOTE: By dividing the groups in this way, the number of patients is each group are not large enough to make statements as to relative outcome that will stand up to rigorous statistical testing.

* Does not included the one patient treated with a Thompson prosthesis.

be high operative risks, i. e. non-surgical candidates, stayed in the hospial a short period of time but were not ambulatory at the time of discharge. The two remaining patients did poorly during their hospital stay and they were never ambulated: The first patient was treated with Knowles pins and suffered a cardiac complication which required placement of a pacemaker. This patient continued to improve at home, as noted in the section on follow up, and had achieved an activity level of five by the end of the study. The second patient was treated with a Thompson prothesis and died shortly after developing intra-operative cardio-respiratory failure.

TABLE 8

Landmarks During Hospital Stay by Treatment Group

POPULATION	DAYS PRIOR TO PROCEDURE	1ST DAY OUT OF BED	1ST DAY P.T.	# DAYS OF P.T.
TOTAL	2.1	3.3	4.9	9.0
(S.D.)	(3.4)	(2.2)	(3.1)	(6.9)
AUSTIN MOORE	3.0	3.8	5.6	10.1
	(3.9)	(2.4)	(3.5)	(5.3)
NAIL OR PIN	2.1	2.3	3.4	8.8
	(1.5)	(1.5)	(1.7)	(4.8)
OTHER TREATMENT *	0.0	3.8 **	4.3***	7.3 ***
	(0.0)	(1.7)	(2.5)	(4.1)

* Does not include the one patient treated with a Thompson prosthesis.
** Does not include two patients that were never ambulated.
*** Does not include three patients the never had physical therapy.

In table 7 the subpopulations are grouped by broader patient categories as follows: Austin-Moore prosthesis, Nail or Pin (includes Massie, Yale, and Knowles) and all other treatment choices. These categories do not include the one patient treated with a Thompson prosthesis. In this table it is apparent that the major difference between these groups is the length of hospital stay. The Nail or Pin group did slightly better post-operatively, than the rest, since they achieved a higher level of activity in fewer days in spite of the poor result of the patient treated with Knowles pins.

Table 8 was designed to show what happened to the subpopulations shown in table 7 during the hospital stay. The total population waited approximately two days for definitive treatment after they had incurred their hip fracture and the average patient did not get out of bed until post operative day three. The average patient received nine days of physical therapy which was instituted on or about post operative day five. The patients treated with an Austin-Moore prosthesis had to wait longer for surgery, stayed in bed longer and required more physical therapy than the rest of the population. The patients listed as "All Other Treatments" includes four patients treated conservatively and two that were non-surgical candidates. Bed rest or traction was the primary treatment for them and it was instituted shortly after admission to the hospital, in other words, the interval prior to treatment was short. Three of the six patients in this group never had physical therapy while in the hospital. The remaining three patients were given aproximately seven days of physical therapy. This was slightly less than the average for all patients. The patients treated conservatively, uniformly carried the diagnosis of impacted intracapsular hip fracture and three of the four became rapidly ambulatory. Ambulation was not a goal for the nonsurgical candidates and therefore, as a result no physical therapy was ordered.

Table 9 shows the patients grouped by age and is most revealing. The level of activity decreases directly with increasing age, while the length of hospital stay seems to be independent of age. Patients below age seventy did extremely well, achieving an activity level of slightly higher than four and staying in the hospital for only fifteen days.

Conversely, patients over ninety did poorly and only achieved a level of one (ability to get out of bed and move only a few feet) while staying for eighteen days.

TABLE 9

Length of Hospital Stay and Activity Level Grouped by Age

POPULATION	#	%	AVERAGE AGE	AVERAGE HOSPITAL STAY	LEVEL OF ACTIVITY
TOTAL	67	100.0	78.4	17.4	2.4
(S.D.)			(11.9)	(7.4)	(1.9)
LESS THAN 70 YEARS	13	19.4	**	15.2	4.2
				(8.5)	(1.7)
FROM 70 TO 79	15	22.4	**	18.7	2.7
				(4.2)	(1.6)
FROM 80 TO 89	29	43.3	**	17.5	2.0
				(8.6)	(1.8)
90 AND OLDER	10	14.9	**	18.2	1.2
				(6.0)	(1.1)

** The data is grouped by age.

The data pertaining to hospital stay are broken down by level of activity at time of discharge. The two groups presented in table 10 are "Low Level" (zero to two) and "High Level" (three to six). This was

TABLE 10

Landmarks During Hospital Stay by Level of Activity at Discharge

POPULATION	DAYS PRIOR TO PROCEDURE	1ST DAY OUT OF BED	1ST DAY P.T.	# DAYS OF P.T.
TOTAL 0-6	2.1	3.3	4.9	9.0
(S.D.)	(3.4)	(2.2)	(3.1)	(6.9)
LOW LEVEL 0 to 2	3.0	4.0	7.2	6.5
	(2.9)	(2.9)	(3.8)	(8.2)
HIGH LEVEL 3 to 6	2.2	2.8	4.8	11.6
	(3.6)	(1.6)	(5.1)	(4.2)

done to simplify the analysis. Grouping the patient population in this way indicates several factors that seem to favor achievement of a higher level of activity at discharge. These factors were: fewer days before surgery, getting out of bed earlier, and early and more frequent physical therapy.

4.3 IN-HOSPITAL COMPLICATIONS AND IN-HOSPITAL MORTALITY

There were twenty-two patients (33 per cent) of the total population that suffered complications during their hospital stay. Four of these twenty-two expired as a result of complications. Within the group of patients with complications six had more than one complication. These in-hospital problems fell under the following seven major categories:

1. Cardiac (nine),
2. Infectious (six),
3. Hematological (six),
4. Urological (five),
5. Neurological (two),
6. Miscellaneous surgical problems (two), and
7. In-hospital mortality (four).

Of the nine patients with cardiac complications three had cardiac arrests (one intra-operatively), two developed acute myocardial infarctions, two patients with congestive heart failure lapsed into pulmonary edema, one had a new onset of hypertension and one ruptured an abdominal aortic aneurysm. One of the patients required a pacemaker after his cardiac arrest. The patient who suffered the intra-operative cardiac arrest expired two weeks after surgery.

The six patients with complications of an infectious nature were subdivided into urinary tract infection (three), fever of unknown origin (one, the fever resolved after a ten day course of erythromycin), bilateral pneumonia (one), and hip wound infection (one). The organisms that were cultured from the hip was Staphlococcus Aureus and Beta Hemolytic Streptococcus. The treatment used for this particular infection was

daily Hubbard Tank baths for debridement, a cephalosporin (Cefoxitin) one gram every four hours and Betadine dressings. The infection cleared after approximately thirty-two days. It should be emphasized that only one of the sixty-one patients (less than 2 per cent) treated surgically had a wound infection. The patient with pneunmonia died of that infection within two weeks.

There were three types of hematological disorders: post-operative anemia (four), pulmonary embolism (one) and disseminated intravascular coagulation (one). The patient with disseminated intravascular coagulation (DIC) died of cardio-respiratory arrest that was a result of the massive blood loss caused by DIC. The patient with pulmonary embolism was treated with Heparin and did well. The patients with anemia required between one and three units of blood post-operatively.

Five patients had urologic problems. One had a new onset of urinary incontinence and one developed urinary retention. There were three others that had urinary tract infections as mentioned before in the group of infectious complications.

The two patients with neurological complications both had delirium tremens (secondary to alcohol withdrawal).

The two patients with miscellaneous postoperative problems included one patient with paralytic ileus and the other dislocated her hip prosthesis twice. After the second dislocation the patient required operative reduction and a Spica cast.

There were four patients who died during hospitalization three of which were treated with Austin-Moore prosthesis and the fourth with a Thompson prosthesis. Two of these patients had cardio-respiratory ar-

rests (the patient treated with the Thompson protheses had her's intra-operatively), one patient died of pnuemonia and the other of a ruptured aortic aneurysm. These four patients are noted by asterisks in table 18.

4.4 MORTALITY

One of the most important concerns after a patient sustains a hip fracture is his or her life span after that incident. In this section the data were organized to elucidate factors influencing survival.

In the population studied, there were many more women than men. Table 11 compares the two sexes with respect to mortality. The male death rate was one and one-half times greater than the female death rate. However, as noted in the table, the calculated value for Chi Squared is approximately two. Based on this statistic the P value is less than .15. Therefore the mortality rates of the two sexes are not statistically different. The death rate for the total population is also shown in table 11, 35.8 per cent of the population studied died during the study period.

The mortality rates shown in table 12 are the result of dividing the patient population by treatment choice. Excluding the patient groups where the number of patients is less than six, the group of patients treated with Austin-Moore prothesis had the highest mortality rate (41.5 per cent). The groups treated with Massie and Yale nails each had equal

TABLE 11

Death Rate in Total, Female and Male Populations

POPULATION	#	%	AVERAGE AGE	# DEATHS OVER STUDY PERIOD	% OF INITIAL POPULATION
TOTAL (S.D.)	67	100.0	78.4 (11.9)	24	35.8
FEMALES	49	73.1	77.6 (12.2)	15	30.6
MALES	18	26.9	80.7 (11.2)	9	50.0

Note: The calculated value for chi squared when evaluating the death rates of the males and females is 2.06. This corresponds to a p value less than .15. Therefore there is little statistical difference between the death rates of the women and the men in the study.

rates which was approximately one third of the rate of those treated with Austin-Moore prostheses. The patients treated conservatively had a death rate of 25 per cent. The non-surgical candidates did not survive the study period while the one patient treated with Knowles Pins survived. Finally, the one patient where a Thompson Prosthesis was used died within the study period.

I have refrained from making statistical statements in reference to table 12, since many of the groups mentioned above contain a very small number of patients. However, in table 13 the patients are grouped in a way that proved to be more meaningful. This grouping allowed for comparison of the collected data to data from published life tables (79). In this table, the groups are "Austin-Moore", "Nail or Pin" and "Other Treatments". The one patient treated with a Thompson prosthesis was not

TABLE 12

Mortality by Treatment Choice

POPULATION	#	%	AVERAGE AGE	# DEATHS OVER STUDY PERIOD	% OF INITIAL POPULATION
TOTAL (S.D.)	67	100.0	78.4 (11.9)	24	35.8
AUSTIN-MOORE	41	61.2	81.9 (8.4)	17	41.5
MASSIE NAIL	12	17.9	70.8 (16.6)	2	16.7
YALE NAIL	6	9.0	71.7 (11.8)	1	16.7
CONSERVA-TIVE TX	4	6.0	67.8 (11.8)	1	25.0
NON-SURG. CANDIDATE	2	3.0	90.5 (9.2)	2	100.0
KNOWLES PINS	1	1.5	90	0	0.0
THOMSON PROSTHESIS	1	1.5	74	1	100.0

NOTE: By dividing the groups in this way, the number of patients is each group are not large enough to make statements as to relative outcome that will stand up to rigorous statistical testing.

included in these groups. Arranging the groups in this way, the term prothesis pertains only to Austin-Moore prostheses and the statements made about this group can therefore be better defined. Refering to table 13, the group denoted by "Nail or Pin" had the lowest death rate and

TABLE 13

Mortality by Treatment Groups

POPULATION	#	%	PREDICTED BY LIFE TABLE	# DEATHS OVER STUDY PERIOD	% OF INITIAL POPULATION
TOTAL (S.D.)	67	100.0	14.7	24*	35.8
AUSTIN-MOORE	41	61.2	10.4	17*	41.5
NAIL OR PIN	19	28.4	2.9	3**	15.8
OTHER *** TREATMENT	6	9.0	1.3	3**	50.0

* P less than .05 when this number is compared to life table data.
** P not less than .05 when this number is compared to life table data.
*** Does not include one patient treated with a Thompson Prosthesis.

the group "Other Treatments" the highest. As described in the section on Materials and Methods, comparisons of these groups to age and sex matched populations from published life tables can be made. In table 13, the actual number of deaths for each group is higher than expected from the life table prediction. The difference is statistically significant (P is less than .05) for the total population and the Austin-Moore group.

The result of grouping the patients by age and the comparison of these data to published life table data is presented in table 14. In

TABLE 14

Mortality Grouped by Age

POPULATION (BY AGE)	#	%	PREDICTED BY LIFE TABLE	# DEATHS OVER STUDY PERIOD	% OF INITIAL POPULATION
TOTAL (S.D.)	67	100.0	14.7	24*	35.8
LESS THAN 70 YEARS	13	19.4	0.5	1**	7.7
FROM 70 TO 79	15	22.4	1.8	3**	20.0
FROM 80 TO 89	29	43.3	7.8	14*	37.9
90 AND OLDER	10	14.9	4.6	6*	60.0

Note: The calculated value of chi squared for the data grouped by age as above is 10.60 if we use the hypothesis that all groups have the same death rate. This corresponds to a p value of less than .02. Therefore the death rates for each of the above subsets of the study population cannot be the same and the result is statistically significant.

* P less than .05 when this number is compared to life table data.

** P not less than .05 when this number is compared to life table data.

each sub-group the actual number of deaths is higher than the predicted value. In the age groups eighty to eighty-nine and ninty and older, these differences are statistically significant. The mortality rate for

patients with intracapsular hip fractures clearly increases with increasing age. The Chi Squared test on these rates, as shown in table 14, confirm that the observed death rates are different and this difference is statistically significant. These resultant rates could not occur because of an error in sampling or because too few subjects were studied.

The next three tables (table 15, 16 and 17) are aimed at correlating death rate with other factors. Table 15 shows death rate as compared to level of activity at time of discharge. The death rate increases with decreasing levels. In addition, when these data are grouped (the last column in the table) an extremely large difference in the moratility rates becomes apparent. Table 16 indicates how the diagnosis of organic brain syndrome affects the death rate. The patients with this diagnosis had a two fold higher mortality rate when compared to those without this diagnosis. In the subpopulation treated with Austin-Moore prosthesis this difference is statistically significant, however in the subpopulation treated with Nail or Pin it is not. In the total population the significance of this difference is great (P is less than .02). In a similar fashion, the location the patient was discharged to was examined in table 17. In the total population and the subpopulation treated with Austin-Moore prosthesis the difference in the death rates indicated are highly significant (P is less than .01). However, in the patient group treated with Pin or Nail there is little or no difference (P is greater than .80).

The final table in this section (table 18) summarizes the cause of death, the age of each patient at the time they fractured their hip, the

TABLE 15

Mortality Corresponding to Discharge Activity Level

Activity Level*	Number of Patients	Dead	Precent Dead	Grouped Activity Levels*
Zero	16	11	69	Number= 31
One	9	4	44	Deaths= 17 or 55%
Two	6	2	33	
Three	16	4	25	Number= 36
Four	9	2	22	Deaths= 7 or 19%
Five	7	0	0	
Six	4	1	25	

* Levels used here are as described in Materials and Methods.

type of treatment they received, and their survival in months after hip fracture. The patients who died during their initial hospitalization

TABLE 16

Outcome Based on Treatment Choice and Diagnosis of OBS *

Treatment Choice	Number of Patients	%	Alive	Dead	Mortality Rate (%)
Austin-Moore: **					
With OBS *	15	39	8	7	46.7
Without OBS *	24	61	20	4	16.7
Nail or Pin: **					
With OBS *	2	11	1	1	50.0
Without OBS *	16	89	14	2	12.5
Total: **					
With OBS *	17	20	9	8	47.1
Without OBS *	40	70	34	6	15.0

* Organic Brain Syndrome

** Does not include patients in study treated in other ways. Does not include the eight patients lost to follow up or those with uncertain disposition. In addition, includes only patients were diagnosis of Organic Brain Syndrome is in the patient's chart. The calculated values of chi squared for each of the above groups is 5.13, 1.76, and 6.08 respectively. The resultant P values are less than .05, .20, and .02.

are noted by an asterisk. The major cause of death was failure of the cardio-respiratory system, with congestive heart failure heading the list. Only four of the twenty-four of the patients or one-sixth died of

TABLE 17

Outcome Based on Treatment and Where Patient is Discharged

Treatment Choice	Number of Patients	%	Alive	Dead	Mortality Rate (%)
Austin-Moore: * Convalescent Home	25	64	14	11	44.0
Patient's Home	14	36	14	0	0.0
Pin or Nail: * Convalescent Home	5	28	4	1	20.0
Patient's Home	13	72	11	2	15.4
Total: * Convalescent Home	30	53	18	12	40.0
Patient's Home	27	47	25	2	7.4

* Does not include patients in study treated in other ways. Does not include the eight patients lost to follow up or those with uncertain disposition. The calculated values of chi squared for each of the above groups is 8.58, .05, and 8.14 respectively. The resultant P values are less than .01, .80, and .01.

diseases completely unrelated to their cardio-respiratory system or to their hip fracture. These are the last four entries in the table.

Four of the twenty-four (16.7 per cent) died during their hospitalization for their hip fracture and a total of ten (41.7 per cent) died within the first three months after the hip fracture. In addition, from

this table it can be seen that almost half (45.8 per cent), of the patients who died, died in the six months after the hip fracture and approximately two-thirds (62.5 per cent) in the first year.

TABLE 18

Cause of Death (Twenty-Four Patients)

Primary Cause of Death	Age at Time of Fracture (Years)	Procedure Used	Months Until Death
Congestive Heart Failure	83	AM	28
	95	AM	26
	82	AM	27
	62	AM	1
	97	NSC	2
Acute Myocardial Infarction	90	AM	8
	77	AM	19
	79	MN	29
Cardio-Pulmonary Arrest	87	AM	1 *
	88	AM	2
	84	NSC	1
Pneumonia	80	AM	0 *
	85	AM	7
	94	AM	32
Cardiac Arrhythmia	96	AM	2
	88	AM	4
Cerebral Vascular Accident	87	AM	1
	85	CT	18
Acute Respiratory Failure	87	MN	24
Intraoperative Cardio-Pulmonary Failure	74	TP	0 *
Gastro-intestinal Bleeding	85	YN	11
Liver Tumor (?type)	83	AM	16
Obstructive Jaundice Secondary to Cancer of the Pancreas	84	AM	10
Rupture of Abdominal Aortic Aneurysm	91	AM	0 *

AM - Austin-Moore Prosthesis
MN - Massie Nail
TP - Thompson Prosthesis
CT - Conservative Treatment
NSC - Non-Surgerical Canidate
* - Died in Hospital post Fracture

4.5 LATE COMPLICATIONS

In reviewing the post fracture course of the patients it was found that twenty-four patients died, as already discussed in the section on mortality. Sixteen patients had a change in their medical condition or suffered a complication of the hip fracture. In addition, of the thirty-five patients alive at the end of this study ten had discomfort in the fractured hip . This section deals with studies of complications not discussed in the section on mortality.

Changes in medical condition can be classified into four types: medical problems, new orthopaedic problems, surgical problems and complications directly related to the inital hip fracture. Several patients had multiple conditions and are listed under more than one category.

Additional diagnoses made during the follow up period included: organic brain syndrome (two, one had a brain tumor pre-operatively), Acute Myocardial infarction (one, two months post-operatively), new onset of angina (one), syncope (one, with many emergency room visits for this condition) and hypertension (one).

Six patients developed new orthopaedic problems (this excludes those patients, discussed later in this section, with complications of the original fracture). Five of these patients fractured other bones. The sixth patient was diagnosed as having Paget's Disease of Bone. Of the five patients who fractured other bones during the study period, two broke their other hip, two fractured some other part of the femur and two fractured more than one other bone.

The first of the two patients with surgical problems had obstructive jaundice. The second developed severe decubitus ulcers on the ipsila-

teral leg of the previous fracture six months after leaving the hospital, resulting in an above the knee amputation, which left the patient non-ambulatory.

There were five patients of the original sixty seven that sustained complications directly related to the inital hip fracture and its repair. In one patient the Massie nail penetrated the joint space (this was demonstrated by a roentgenogram) and that patient required a total joint replacement. In another patient in the Massie nail group the nail cut out of the femur on the forty-first post-operative day (after the patient was discharged). Because of the patient's poor health at the time of complication no further surgical treatment was offered and the patient became non-ambulatory. One patient treated with an Austin-Moore prosthesis had an infection in that hip, which required removal of the prosthesis six months after the its insertion. This patient was also left non-ambulatory as a result of the second operation. Another patient in the Austin-Moore group dislocated her prosthesis in the hospital (as mentioned in the section on in hospital complications) and developed severe skin breakdown as a result of the Spica cast used in her treatment. The one patient in this section who was treated with a Yale nail was diagnosed by roentgenogram as having avascular necrosis fifteen months post-operatively. This condition was treated by excising the femoral head and replacing it with a Bateman prosthesis. The patient did well for a few months achieving an activity level of six. However, within six months the hip became increasingly painful and the patient's activity level is now only three.

There were no patients with documented non-union in this study.

The last group of patients complained of hip pain as their only complication. Their symptoms ranged from occasional aches to severe pain limiting daily activities. These symptoms were treated in several ways. Some patients required no treatment, others took aspirin or acetomeniphen (Tylenol) for occasional pain (one to eight daily), and one required a codeine preparation (Percocet) for relief of severe discomfort.

4.6 LONG TERM FOLLOW UP

The level of activity at time of final follow up and factors related to that level were examined. All data presented here were the result of analyses of the information collected on the patients living at the end of the study. Data on the eight patients lost to follow up and on the twenty-four patients that were no longer living were not used.

The approach taken to evaluate the factors influencing patient outcome (activity levels), was to group the patients by outcome and examine the factors that pertain to each of the outcome groups. This is shown in table 19. In this table, the patients are divided into their levels of activity at the end of the study. The mean value as well as the standard deviation is recorded for each factor. The factors are: age at time of fracture (AGE), the number of days prior to the procedure (DAYS BEFORE), the length of hospital stay (LENGTH OF STAY), the number of days after the procedure before the patient was allowed out of bed (1ST DAY O.O.B.), the number of days prior to the start of physical therapy (1ST DAY P.T.), and the length of the physical therapy (LENGTH OF P.T.).

From this table it is apparent that the patients with a lower level (less than three) were in general older, waited longer for their procedure and had a longer hospital stay than the patients with a higher level (above three). The level three has been excluded because there is only one patient in that group. The patients that did better (level four and higher) were out of bed earlier and had earlier physical therapy than their counterparts. Both groups had approximately the same amount of physical therapy which implies that it is a less important factor with respect to outcome.

Level of activity for patients at the end of the study, broken down by treatment choice is shown in table 20. Here, as in previous sections, there are differences between the group of patients treated with Austin-Moore prosthesis and the patients treated with nail or pins. The Austin-Moore patient group averaged a level of two. Patients treated with Massie or Yale nails averaged an activity level of four. The one patient treated with Knowles pins did slightly better with a level of five and the patients treated conservatively did worse than all the rest, achieving a level of one. If the patients are grouped into Austin-Moore prosthesis versus all of the patients treated with nail or pins, the calculated T statistic is 2.84 and the level of significance (P value) is less than .01. Therefore, the patients treated with either nail or pins did much better than the patients treated with an Austin-Moore protheses in respect to the level of activity. This difference is statistically significant.

TABLE 19

Level of Activity at Final Follow Up Correlated with Other Factors

* *

FACTOR	LEVEL OF ACTIVITY						
	0	1	2	3	4	5	6
AGE	83 (7)	81 (6)	72 (13)	84 (0)	73 (12)	75 (13)	66 (18)
DAYS BEFORE	3 (4)	6 (5)	3 (2)	0 (0)	2 (2)	2 (2)	1 (1)
LENGTH OF STAY	23 (11)	20 (7)	18 (5)	12 (0)	15 (4)	18 (5)	14 (3)
1ST DAY O.O.B.	4 (2)	6 (7)	3 (1)	5 (0)	2 (1)	2 (1)	3 (2)
1ST DAY OF P.T.	4 (2)	7 (7)	5 (2)	5 (0)	3 (2)	8 (12)	5 (2)
LENGTH OF P.T.	12 (11)	10 (8)	11 (4)	7 (0)	10 (5)	12 (6)	8 (3)
NUMBER OF PATIENTS	7	4	5	1	3	9	6

O.O.B. is Out Of Bed.
P.T. is Physical Therapy.
Standard Deviations are in Parentheses.

To examine the relationship between discharge location (i.e., home or extended care facility) and levels of activity at follow up, a tabula-

TABLE 20

Treatment Choice Correlated with Final Follow Up Level

TREATMENT	NUMBER OF PATIENTS ALIVE	AVERAGE LEVEL AT FOLLOW UP	STANDARD DEVIATION
AUSTIN MOORE	22	2	2
MASSIE NAIL	5	4	2
YALE NAIL	5	4	2
KNOWLES PINS	1	5	0
CONSERVATIVE TREATMENT	2	1	0
ALL PATIENTS ALIVE AT END OF STUDY	35	3	2

tion was made of the activity levels and locations of the patients (table 21). There are many more patients at home with levels higher than three than in extended care facilities. Conversely there are many more patients at a low level of activity in a convalescent home than at home. In other words, the patients at home are doing better than the patients in an extended care facility. This result is statistically highly significant (P is less than .001).

TABLE 21

Activity Level Correlated with Patient Location at Last Follow Up

* *

LOCATION	LEVEL OF ACTIVITY							
	0	1	2	3	4	5	6	
AT HOME	1	0	1	0	2	8	6	
CONVAL. HOME	6	4	4	1	1	1	0	
TOTAL	7	4	5	1	3	9	6	
%	20.0	11.4	14.3	2.9	8.6	25.7	17.1	

CHI SQUARED = 22.1 WITH 6 DEGREES OF FREEDOM
SIGNIFICANCE = .001

To examine the relationship between the diagnosis of organic brain syndrome and level of activity, the patients were tabulated again in a similar way. In table 22 the results of this tabulation is shown. Here, it is apparent that patients without organic brain syndrome do better than the ones with this diagnosis. This result is highly significant (P is less than .1).

The next table (number 23) answers two questions of interest. First, how does the average activity level at discharge compare to the average level at final follow up? Second, how much improvement or decline can

TABLE 22

Level of Activity at Final Follow Up Correlated with O.B.S.

* *

LEVEL OF ACTIVITY VERSES DIAGNOSIS OF ORGANIC BRAIN SYNDROME (OBS)

DX. OF OBS	LEVEL OF ACTIVITY						
	0	1	2	3	4	5	6
WITHOUT OBS	1	0	5	1	3	9	6
WITH OBS	6	4	0	0	0	0	0
TOTAL	7	4	5	1	3	9	6
%	20.0	11.4	14.3	2.9	8.6	25.7	17.1

CHI SQUARED = 10.5 WITH 6 DEGREES OF FREEDOM
SIGNIFICANCE (P) = .1

one expect for the average patient? From the values indicated in the table, there is little difference in the two groups when considering all patients. The difference between the means shown are not statistically significant (for both living patients only and for all patients). The average difference between the two levels, at discharge and at the time of final follow up, is 0.5. This is an indication that any given patient can expect only minimal improvement in function after leaving the hospital. It also means that the patient will probably not decline with respect to the discharge activity level. However, the variability of this value is large (approximately two) and the statements made above can only be used to indicate a trend in the data. The scattergram (figure 4) shows that the level of activity at discharge and at follow up

TABLE 23

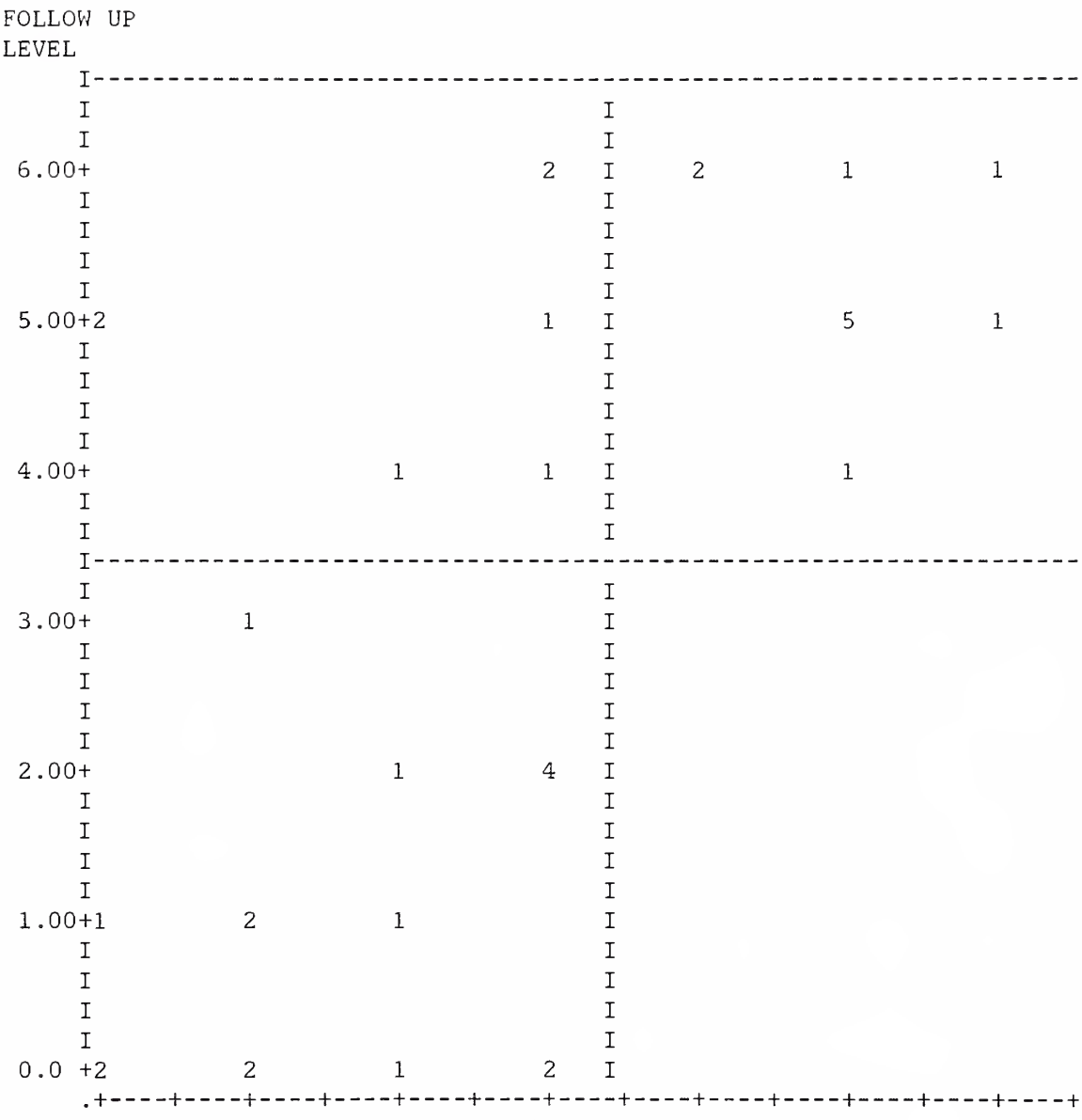
Comparison of Level of Activity at Discharge to Level at Time of Follow Up

TIME LEVEL EVALUTATED	AVERAGE LEVEL	(STANDARD DEVIATION)
ALL PATIENTS		
AT DISCHARGE	2.4	(1.9)
LATEST FOLLOW UP	2.7	(2.3)
LIVING PATIENTS AT END OF STUDY ONLY		
AT DISCHARGE	2.8	(1.8)
AT END OF THE STUDY	3.1	(2.2)
ALL PATIENTS		
AVERAGE DIFFERENCES DISCHARGE LEVEL TO FOLLOW UP*	0.5	(1.9)

* This is caluated be subtracting the level of activity at discharge from the level of activity at final follow up and averaging the resultant differences.

are positively correlated. However, the coefficient of correlation is .61, not a very strong correlation. Again this information is useful for examining trends in the data.

ACTIVITY LEVEL AT TIME OF FOLLOW UP (X) VERSES
ACTIVITY LEVEL AT TIME OF DISCHARGE (Y)



STATISTICS..

CORRELATION (R)-	.61	R SQUARED -	.37
INTERCEPT (A) -	1.03	SLOPE -	.89
PLOTTED VALUES -	35 *		

* Does not include the eight patients lost to follow up or the twenty-four patients that died.

Figure 4: Scattergram Showing Level of Activity at Discharge and Level at Time of Follow Up

4.7 PHYSICIANS TREATMENT PREFERENCE

The thirteen physicians who treated the patients included in this study had varied treatment preferences. They are shown in table 24. It is interesting to note that no physican treating more than one patient used less than two different treatment modalities. When an internal fixation device was chosen, the choice was exclusive, i.e., physicians using the Yale nail did not use the Massie nail and physicians using the Massie nail did not use the Yale nail.

TABLE 24

Treatment Preference By Physician

PHYSICIAN	# PTS	TREATMENTS CHOSEN						
		AM	MN	YN	KP	TP	CT	NSC
1	14	10	2	0	1	0	0	1
2	8	5	0	3	0	0	0	0
3	6	5	0	0	0	0	1	0
4	1	1	0	0	0	0	0	0
5	4	2	1	0	0	1	0	0
6	1	1	0	0	0	0	0	0
7	10	4	5	0	0	0	1	0
8	8	4	2	0	0	0	1	1
9	5	4	0	0	0	0	1	0
10	1	0	1	0	0	0	0	0
11	2	1	0	1	0	0	0	0
12	4	2	0	2	0	0	0	0
13	3	2	1	0	0	0	0	0
TOTAL	67	41	12	6	1	1	4	2

AM - Austin-Moore Prosthesis
CT - Conservative Treatment
KP - Knowles Pins
MN - Massie Nail
NSC - Non-Surgerical Canidate
TP - Thompson Prosthesis
YN - Yale Nail

Chapter V

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

1. The mortality for all patient groups was higher than predicted from the Life Tables using an age and sex matched population for comparison.
2. In this study approximately one-half (45.8 per cent) of the patients to die after their intracapsular hip fracture do so in the first six months.
3. When comparing men and women with respect to age, length of hospital stay, timing of physical therapy, length of physical therapy, or mortality there were no statistical differences in the patient population studied. In other words, sex does not have predictive value with respect to any of the above parameters.
4. Treatment choice played a large role in determining the final outcome in the cases studied. At time of final follow up, the patients treated with Nail or Pins had a much higher level of activity (functional capacity) than the patients treated with the Austin-Moore Prosthesis. The Nail or Pins group also had a shorter hospital stay, and required less physical therapy in order to obtain a better long term result. The mortality rate of the Austin-Moore group was more than twice the mortality rate of the Nail or Pins group. The Austin-Moore group had far fewer late complications directly related to the hip fracture and its repair than the Nail or Pins group (4.8 per cent of the Austin-Moore group as compared to 16.5 per cent of the Nail or Pins group).

5. Death rate increased directly with increasing age. Increased age corresponded to decreased level of activity at discharge.
6. Several factors favor a higher level of activity at discharge for all patients. They were fewer days until surgery, getting out of bed earlier, and earlier and frequent physical therapy.
7. The level of activity scale devised in this paper has predictive value with respect to mortality and long term outcome. A low level at discharge is associated with a higher mortality rate. The level of activity at discharge is positively correlated with the level of final follow up.
8. Organic brain syndrome is associated with poor results at final follow up and a high mortality rate (47 per cent).
9. Being discharged to an extended care facility (versus the patient's home) is associated with a statistically higher mortality rate (except in the patients treated with Nail or Pins).
10. At the final follow up the following factors correlated with good results: lower age, shorter wait until surgery and shorter time in bed post operatively.
11. The length of hospital stay and length of physical therapy did not correlate with long term outcome.
12. Level of activity at discharge, on the average, was improved upon only slightly during the period of follow up.

5.2 RECOMMENDATIONS

1. If reduction and internal fixation is an option the use of Nail or Pins is preferable to a prothesis since the higher rate of technique related complications with Nail or Pins is greatly offset by superior long term results.
2. If operative treatment is chosen, an early procedure done in the first two days is preferable since it is correlated with a better functional result (higher level of activity).
3. Early ambulation is recommended since it is correlated with a better functional result.
4. Early physical therapy is recommended since it is correlated with a better functional result.
5. Discharging the patient to his or her home is recommended since it is correlated with a better final outcome than sending him/her to a long term care facility.
6. Little improvement of activity levels can be expected after hospital discharge. Therefore achieving high levels of activity in the hospital should be emphasized.

Appendix A

PROGRAM USED IN DATA ANALYSIS

PROGRAM IN BASIC FOR CALCULATION OF THE T STATISTIC

```
00010 rem this program is by a.m.reznik on 12/20/82
00020 print 't-test program rev. 3 '
00030 rem **********now input the number of patients, the mean and
00040 rem            the standard deviation---------------
00050 Print 'what is N1,X1,S1'
00060 input rn1,x1,s1
00070 Print 'what is N2,X2,S2'
00080 input rn2,x2,s2
00090 rem echo the original data.
00100 print 'data echo: N1,X1,S1=',rn1,x1,s1
00110 print '           N2,X2,S2=',rn2,x2,s2
00120 rem
00130 rem now calculate the t statistic
00140 rem This statistic formula is from: Paul G. Hoel,
00150 rem Introduction to Mathematical Statistics, Fourth ed.
00160 rem John Wiley and Sons Inc., N.Y. First Printing 1947
00170 rem
00180 d1 = s1**2/rn1
00190 d2 = s2**2/rn2
00200 d = d1 + d2
00210 t = abs(x1-x2)/sqr(d)
00220 rem
00230 rem now calculate the degrees of freedom (df).
00240 realdf = (d**2/(d1**2/(rn1+1)+d2**2/(rn2+1))) - 2
00250 df = int(realdf)
00260 rem
00270 rem
00280 print 'the degrees of freedom for this test is:',df
00290 print '******** the value calculated for t is =',t
00300 rem
00310 print 'another test of two means (yes=1)'
00320 rem start again if another test is desired. (go to 30)
00330 input a
00340 if a=1 then go to 50
00350 rem
00360 print '*************************************************'
00370 rem end of program
00380 print '*************************************************'
00390 end
```

Figure 5: T-test Program

Appendix B

STATISTICS USED IN DATA ANALYSIS

Equation for the T statistic:

$$T = (M1-M2) \Big/ \sqrt{\frac{S1^2}{N1} + \frac{S2^2}{N2}}$$

. AND DF =

$$\frac{\left(\frac{S1^2}{N1} + \frac{S2^2}{N2}\right)^2}{\frac{\left(\frac{S1^2}{N1}\right)^2}{(N1+1)} + \frac{\left(\frac{S2^2}{N2}\right)^2}{(N2+1)}} - 2$$

where N1 = number of patients in group 1
N2 = number of patients in group 2
M1 = mean 1 in group 1
M2 = mean 2 in group 2
S1 = standard Deviation in group 1
S2 = standard Deviation in group 2

Equation for the Chi Squared Statistic (X^2):

$$X^2 = \sum_{i=1}^{\text{to N}} \frac{(Oi - Ei)^2}{Ei}$$

where Oi = observed result for group i
Ei = expected result for group i
N = Total number of groups

Equation for the Coefficient of Correlation (R):

$$Sxy = (1/N-1) \times (\Sigma Xi \times Yi - 1/N \times \Sigma Xi \times \Sigma Yi)$$

$$Sx = \sqrt{\Sigma Xi^2 - (\Sigma Xi)^2/N \,/\, (N-1)}.$$

$$Sy = \sqrt{\Sigma Yi^2 - (\Sigma Yi)^2/N \,/\, (N-1)}.$$

$$R = \frac{(Sxy)}{(Sx) \times (Sy)}$$

where $-1 < R < +1$

slope (S):

$$S = \frac{\Sigma XiYi - (\Sigma Xi \Sigma Yi)/N}{\Sigma Xi^2 - (\Sigma Xi)^2/N}$$

Intercept (I):

$$I = (\Sigma Yi)/N - (S) \times (\Sigma Xi)/N$$

where N = Number of pairs Xi,Yi
Xi = X value of the ith case
Yi = Y value of the ith case

Varience of a Poisson Distribution (V):

$$V = (\Sigma Xi)/N$$

Standard deviation of a Poisson Distribution (S.D.):

$$S.D. = \sqrt{(\Sigma Xi)/N}.$$

Standard Error of the Mean in a Poisson Distribution (S.E.):

$$S.E. = \frac{((\Sigma Xi)/N) - Me}{\sqrt{(\Sigma Xi)/N}}.$$

where
- Xi = X value of the ith case
- N = number of values
- $(\Sigma Xi)/N$ = mean of Xi for all i
- Me = ideal or expected mean

Appendix C

LIST OF TABLES

LIST OF TABLES

Appendix D

LIST OF FIGURES

LIST OF FIGURES

BIBLIOGRAPHY

1. Altner, P. C.: How Not to Pin a Hip. International Surgery, 63:11, 1978.

2. Banks, H. H.: Factors Influencing the Result in Fracture of the Femoral Neck. Journal of Bone and Joint Surgery, 44A:931, 1962.

3. Barnes, R., Brown, J. T., Garden, R. S., Nicoll, E. A.: Subcapital Fractures of the Femur: A Prospective Review. Journal of Bone and Joint Surgery 58B:2, February 1976.

4. Bonfiglio, M., Voke, E. M.: Aseptic Necrosis of the Femoral Head and Non-Union of the Femoral Neck. Journal of Bone and Joint Surgery, 50A:48, January 1968.

5. Boyd, H. B., Brindley, H. H.: Non-Union of the Neck of the Femur: Study of Three Hundred Forty Seven Cases. A. M. A. Archives of Surgery, 65:169-179 July 1952.

6. Briggs, H.: Sleeve Plate for Hip Fractures. Exhibit at 1950 meeting of A.A.O.S.

7. Brownlee, K. A.: Statistical Theory and Methodology in Science and Engineering. Second Edition, John Wiley and Sons Inc., New York, 1965.

8. Carlsson, A. S.: 351 Total Hip Replacements According to Charnley. Acta Orthopaedica Scandinavia, 52:339, 1981.

9. Ceder, L., Ekelund, L., Inerot, S., Lindberg, L. Odberg, E., Sjolin, C.: Rehabilitation in the Elderly After Hip Fracture. Acta Othopaedia Scandinavia, 50:681, 1979.

10. Ceder, L., Thorngen, K., Wallden, B.: Prognostic Indicators and Early Home Rehabilitation in Elderly Patients with Hip Fractures. Clinical Orthopaedics and Related Research, 152:173, October, 1980.

11. Ceder, L., Svensson, K., Thorgren, K.: Statistical Prediction of Rehabilitation in Elderly Patients With Hip Fractures. Clinical Orthopaedics and Related Research, 152:185, October 1980.

12. Chapman, M. W., Stehr, J. H., Eberle, C. F., Bloom, M. H., Bovill, E. G.: Treatment of Intracapsular Hip Fractures by the Deyerle Method. Journal of Bone And Joint Surgery 57A:735, Septeber 1975.

13. Charnley, J., Blockly, N. J., Purser, D. W.: The Treatment of Displaced Fractures of the Neck of the Femur by Compression. Journal of Bone and Joint Surgery, 39B:45, February 1957.

14. Coates, R. L., Armour, P.: Treatment of Subcapital Femoral Fractures by Primary Total Hip Replacement. Injury, 11:132, November 1979.

15. Cooper, A.: Fractures of the Neck of the Thigh Bone in: A Treatise on Disclocations and on Fractures of the Joints (Second Edition), Landen, Longman and Hurst, 1823. (Reprinted in Clinical Orthopaedics and Related Research, 92:3, May 1973).

16. Crawford, H. B.: Experience with Non-Operative Treatment of Impacted Fractures of the Neck of the Femur. Journal of Bone and Joint Surgery, 47A:830, June, 1965.

17. Davis, G. G.: An Operation for Ununited Intracapsular Fractures of the Neck of the Femur. University Medical Magazine (Philadelphia) 13:507, 1900.

18. Deyerle, W. M.: Absolute Fixation with Contact Compression in Hip Fractures. Clinical Orthopaedics, 13:279, Spring 1959.

19. Deyerle, W. M.: Plate and Peripheral Pins in Hip Fractures. Curr. Pract. Orthopaedic Surgery 3:173, 1966.

20. Deyerle, W. M.: Impacted Fixation over Resilient Multiple Pins. Clinical Orthopaedics and Related Research, 152:102, October 1980.

21. Dillman, D. A.: Mail and Telephone Surveys the Total Design Method. Wiley Interscience, New York, 1978

22. Doyen, A., Judet, R.: Donnes Experimentales Sur le Greffon Pedicule dan les Fractures du Col du Femur: Epanles Fractures du Col du Femur. Paris, Masson et Cie, 1963.

23. Fielding, J. W., Wilson, H. J., Zickel, R. E.: A Continuing End-Result of Intracapsular Fracture of the Neck of the Femur. Journal of Bone and Joint Surgery, 44A:965, July 1962.

24. Fielding J. W.: The Telescoping Pugh Nail in Surgical Management of the Displaced Intracapsular Fracture of the Femoral Neck. Clinical Orthopaedics and Related Research, 152:123, October 1980.

25. Frankel, V. H.: The Femoral Neck, Function, Fracture Mechanism, and Internal Fixation: An Experimental Study. Springfield, Illinois, Charles C. Thomas, 1960.

26. Gallagher, J. C., Melten, L. J., Riggs, B. L., Bergstrath, E.: Epidemiology of Fractures of the Proximal Femur in Rochester, Minnesota. Clinical Orthopaedics and Related Research, 150:163, July - August, 1980.

27. Gallagher, J. C., Melton, L. J., Riggs, B. L.: Examination of Prevalence Rates of Possible Risk Factors in a Population With a Fracture of the Proximal Femur. Clinical Orthopaedics and Related Research, 153:158, November - December, 1980.

28. Garden, R. S.: Low Angle Fixation in Fractures of the Femoral Neck. Journal of Bone and Joint Surgery, 43B:647, November 1961.

29. Garden, R. S.: Stability and Union in Subcapital Fractures of the Femur. Journal of Bone and Joint Surgery, 46B:630, 1964.

30. Garden, R. S.: Malreduction and Avascular Necrosis in Subcapital Fractures of the Neck of the Femur. Journal of Bone and Joint Surgery 53B:183, May 1971.

31. Garden, R. S.: Reduction and Fixation of Subcapital Fractures of the Femur. Orthopaedic Clinics of North America, 5:683, October 1974.

32. Gross, S. O.: A System of Surgery, (Volume Two), Philadelphia, Blanchard and Lea, 1859, Pg. 232.

33. Hamilton, F. H.: Practical Treatise on Fractures and Dislocations 6th Am. Ed. 1880 exerpt reprinted in Speed, K.: The Unsolved Fracture. Journal of Surgical Gynecology and Obstetrics 60:341, 1935.

34. Hinckey, J. J., Day, P. L.: Comparison of Judet and Intramedullary Type Prothesis in Non Union of Hip Fractures. Southern Med. J.: 48:1158, November 1955.

35. Hinckey, J. J., Day, P. L.: Primary Prosthetic Replacement in Fresh Femoral Neck Fractures. Journal of Bone and Joint Surgery. 46A:223, March 1964.

36. Hoel, P. G.: Introduction to Mathematical Statistics, Fourth Edition. John Wiley and Sons, Inc. New York, 1971.

37. Hunter, G. A.: A Comparison of use of Internal Fixation and Prosthetic Replacement for Fresh Fractures of the Neck of the Femur. British Journal of Surgery, 56:229, March 1969.

38. Inman, V. T.: Functional Aspects of the Abductor Muscles of the Hip. Journal of Bone and Joint Surgery, 29:607, July, 1947.

39. Judet, R.: Traitement des fractures du Col du Femur par Greffe Pediculee. Acta. Orthopedia Scandinacia, 32:421, 1962

40. Knowles, F. L.: Fractures of the Neck of the Femur. Wisconsin Medical Journal, 35:106, 1936.

41. Konig, F. in a discussion on von Langenbeck: Verhandlungs Band Deutschen Gesellsch Chirurgie. 1878.

42. von Langenbeck: Verhandlungs Band Deutschen Gesellsch Chirurgie. 1878.

43. Leadbetter, G. W.: Closed Reduction of Fractures of the Neck of the Femur. Journal of Bone and Joint Surgery, 20:108, January 1938.

44. Lewinnek, G. E.: Kelsey, J., White, A. A., Kreiger, N. J.: The Significance and a Comparative Analysis of the Epidemiology of Hip Fractures. Clinical Orthopaedic and Related Research, 152:35, October 1980.

45. Malkin, S., Frankenburg, F.: Fractures of the Hip: A Three Year Survey in One Hospital, Including Experience with the Pugh Nail Procedure. Journal of The American Geriatrics Society, 26:506, 1978

46. Martens, M., Van Audekercke, R., Mulier, J. C., Stuych, J.: Clinical Study on Internal Fixation of Femoral Neck Fractures. Clinical Orthopaedics and Related Research, 141:199, June 1979.

47. Martin: Über Experimentelle Pseudarthrosenbildung und die Bedeutung von Periost und Mark. Arch. f. Klin. Chir. 114:664, 1920.

48. Massie, W. K.: Functional Fixation of Femoral Neck Fracture: Telescoping Nail Technique. Clinical Orthopaedics 12:230, Fall 1958.

49. Massie, W. K.: Treatment of the Femoral Neck Fractures Emphasizing Long Term Follow-up Observations. Clinical Orthopaedics and Related Research, 92:16, May 1973.

50. Meyers, M. H., Harvey, J. P., Tillman, M. M.: The Muscle Pedicle Bone Graft in Treatment of Displaced Fractures of the Femoral Neck: Indications, Operative Technique, and Results. Orthopedic Clinics of North America, 5:779, October 1974.

51. Austin-Moore, T.: Fracture of the Hip Joint (intracapsular): A New Method of Skeletal Fixation. Journal South Carolina Medical Association, 30:199, 1934.

52. Austin-Moore, T.: Metal Hip Joint. A New Self-Locking Vitallium Prosthesis. Southern Medical Journal, 45:1015, November 1952.

53. Godoy-Moreira: A Special Stud-Bolt Screw for Fixation of the Neck of the Femur. Journal of Bone and Joint Surgery, 22:683, 1940.

54. Müller, W.: Experimentelle Untersuchungen über Mechanisch Bedingte Umbildungsprozesse am Wachsenden und Fertigen Knochen und ihre Bedeutung fur die Pathologie des Knochens, Insbesondere der Epiphysenstorungen bei Rachitisahnlichen Erkrankungen. Beitr. z. Klin Chir. 127:251, 1922.

55. Nie, N. H., Hull, C. H., Jenkins, J. G., Steinbrenner, K., Bent, D. H.: Statistical Package for the Social Sciences. Second Edition. McGraw-Hill Book Company, New York, 1975.

56. Newman, J. R.: The World of Mathematics, Simon and Schuster, New York, 1956.

57. Nicolaysen, J.: Lidt om Diagnosen og behandlingen af fractura colli femoris. Nord. Med. Arkiv., 8:1, 1897.

58. Owen, R. R., Melton, L. J., Gallagher, J. C., Riggs, B. L.: The National Cost of Acute Care of Hip Fractures Associated with Osteoporosis. Clinical Orthopaedics and Related Research, 150:172, July - August, 1980.

59. Pauwels, F.: Biomechanics of the Locomotive Apparatus. (English translation of original article from 1935 in German.) Springer-Verlag, New York, 1965.

60. Phemister, D. B.: The Pathology of Ununited Fractures of the Neck of the Femur with Special Reference to the Head. Journal of Bone and Joint Surgery, 21:681, July, 1939.

61. Phillips, D. S.: Basic Statistics for Health Science Students, W. H. Freedman and Company, San Fransisco, 1978.

62. Pierce, R. O., Powell, S. G.: The Treatment of Fractures of the Hip by Roger Anderson Well Leg Fraction. Clinical Orthopaedics and Related Research, 151:165, September 1980.

63. Pugh, W. L.: A Self Adjusting Nail Plate for Fractures about the Hip Joint. Journal of Bone and Joint Surgery. 37A:1085, October 1955.

64. Rydell, W. W.: Forces Acting on Femoral Head Prosthesis. Copenhagen, Manksgard, 1966.

65. Schneck, M.: Intracapsular Fractures of the Femoral Neck: Comminution of the Posterior Neck Cortex as a Cause of Unstable Fixation. Journal of Bone and Joint Diseases, 41A:1187, 1959.

66. Schumpeldick, W., Jantzen, P. M.: A New Principle in the Operative Treatment of Trochenteric Fractures of the Femur. Journal of Bone and Joint Surgery. 37A:693, 1955.

67. Senn, N.: Recent Progress in Surgery; Report to the Wisconsin State Medical Soceity. Milwalkee, 44:80, 1881 (reprinted from The Transaction of the Wisconsin Medical Soceity).

68. Sherk, H. H., Snape, W. J., Loprete, F. L.: Internal Fixation versus Nontreatment of Hip Fractures in Senile Patients. Clinical Orthopaedics and Related research, 141:196, June 1979.

69. Sim, F., Stauffer, R.: Management of Hip Fractures by Total Hip Arthroplasty. Clinical Orthopaedics and Related Research, 152:191, October 1980.

70. Smith-Petersen, M. N., Cane, E., van Gorder, G.: Intracapsular Fractures of the Neck of the Femur: Treatment by Internal Fixation. Arch. Surgery, 23:715, November 1931.

71. Solomon, L.: Osteoporosis and Fracture of the Femoral Neck in South African Bantu, Journal of Bone and Joint Surgery. 50B:2, 1968.

72. Southwick, W. O., Weil, U. H.: personal communication.

73. Speed, K.: The Unsolved Fracture. Surgical Gynecology and Obstetrics, 60:341, 1935.

74. Squire, L. F.: Fundamentals of Roentgenology. Cambridge Mass., Harvard University Press, 1964.

75. Thompson, F. R.: Two and a Half Years Experience with a Vitallium Intramedullary Hip Prothesis. Journal of Bone and Joint Surgery 36:489, June 1954.

76. Thornton, L.: The Treatment of Trochanteric Fractures: Two New Methods. Pedmont Hospital Bulletin, 10:21, 1937

78. Tronzo, R. G.: Surgery of the Hip Joint, Philadelphia, Lea and Febiger, 1973.

77. Tronzo R. G.: Hip Nails for all Occations. Orthopaedic Clinincs of North America 5(3):479, July 1974.

79. United States Department of Health and Human Services: Life Tables for the United States 1900-2050, Acturial Study 87, Table 3i Life Table for Calendar Year 1980. SSA Publication No. 11-11534, September 1982.

80. United States Department of Health and Human Services: ICD-9-CM (International Classification of Disease Ninth Revision, Clincal Modification. Second Edition, September 1980, pg. 755-756.

81. Venable, Charles S., Stuck, W. G.: The Internal Fixation of Fractures. Charles C. Thomas, 1947.

82. Walter, H.: Die klinische Bedeutung der Umbauzonen des Knochens. Arch. f. Klin, Chir. 178, 1933.

83. Whitman, R.: A New Treatment for Fractures of the Neck of the Femur. Med. Rec. 65:441, 1904.

84. Willich: Experimentelles uber Knochenregeneration und Pseudarthrosenbildung. Arch. f. Klin. Chir., 123:203, 1923.

85. Zucherman, J. D.: The Internal Fixation of Intracapsular Hip Fractures: A Review of the First One Hundred Years. Orthopaedic Review 11:85, November 1982.

YALE MEDICAL LIBRARY

Manuscript Theses

Unpublished theses submitted for the Master's and Doctor's degrees and deposited in the Yale Medical Library are to be used only with due regard to the rights of the authors. Bibliographical references may be noted, but passages must not be copied without permission of the authors, and without proper credit being given in subsequent written or published work.

This thesis by has been used by the following persons, whose signatures attest their acceptance of the above restrictions.

RKadish	4/19/85
NAME AND ADDRESS	DATE
RKadish YMSIII	10-20-86