UNIVERSITY OF ALBERTA

PREDICTION OF POSTOPERATIVE DELIRIUM IN ELDERLY PATIENTS UNDERGOING ELECTIVE AND NON-ELECTIVE ORTHOPEDIC SURGERY

BY

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "Prediction of Postoperative Delirium in Elderly Patients Undergoing Elective and Non-elective Orthopedic Surgery" submitted by Bruce W. Fisher in partial fulfillment of the requirements for the degree of Master of Science in Experimental Medicine.

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ABSTRACT

Objectives

To compare the incidence, and severity of postoperative delirium (POD) in elderly patients undergoing elective or non-elective (fracture repair) orthopedic procedures, and to identify potential preoperative risk factors for POD.

Design

Prospectively studied cohort of elective orthopedic procedure patients compared with retrospectively studied (chart review) cohort of non-elective fracture repair patients, in the setting of a university teaching hospital. All enrolled patients were aged 60 years or older and English speaking. The elective cohort included 80 patients who attended a preadmissions clinic prior to orthopedic surgery. The non-elective cohort included 66 patients undergoing fracture repair.

Measurements

Patients consecutively enrolled in the elective study underwent same-day screening which included medical assessment, cognitive and activity of daily living assessment with standardized instruments, and HMPAO SPECT brain scanning. Patients were followed post-operatively by means of daily visits and twice daily telephone interviews with attending nurses, using a modified confusion assessment model (CAM) questionnaire, and repeated cognitive testing and SPECT scanning. Suspected delirium was verified by direct physician assessment. .

Charts of all patients > 60 years of age and admitted to the same hospital during this period for non-elective fracture repair were reviewed for evidence of delirium, based on physician or nurses' diagnoses, or chart documentation of behavior sufficient to satisfy the DSM-III-R criteria.

Results

The elective group had significantly fewer total (17.5% versus 50%, $p < 0.0001$) and severe (7.5% versus 34.3%, $p<0.0001$) cases of POD. All patients recovered prior to discharge and causes were determined in 36% of cases. In the elective group male gender ($p = 0.0095$), and preoperative clock drawing test results of ≤ 6 ($p = 0.0096$) were significantly associated with the development of POD.

In the non-elective group greater age ($p = 0.0034$), greater number of significant pre-existing medical problems ($p = 0.0013$), preoperative delirium ($p = 0.0027$) or dementia ($p = 0.0024$) and pre-admission residence in a chronic care facility ($p = 0.0004$) were all significantly associated with the development of POD, and were significantly more common than in the elective group.

Preliminary analysis showed no significant differences between SPECT scan results of delirious or non-delirious patients.

Conclusion

The significantly lower incidence of POD in the elective group parallels findings in other intervention studies, and may represent modification or reduction of risk factors to a "baseline value" through selection of medically, functionally, and cognitively well patients and by interventions incorporated into the elective study protocol. Two simple models incorporating two [elective setting] or five [non-elective setting] risk factors may be used to preoperatively identify those elderly persons at greatest risk for POD. Validation and refinement of these risk assessment models should be done in a prospective trial.

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Chapter One

1.1 Introduction

Although Celsus coined the term "delirium" and Hippocrates reported disturbances in the sleep-wake cycle as a feature of the condition, the first systematic description of postoperative delirium was offered by Baron Dupuytren in 1834:

> "An operation, gentlemen, may have been performed in the most dexterous manner; yet not withstanding the life of the patient may be threatened by the supervention of very severe accidents.... the brain itself may be overcome by pain, terror or even joy, and reason leaves the patient at the instant when it is most necessary to his welfare that he should remain calm and undisturbed....Nervous delirium although its causes are obscure, its progress uncertain, and the symptoms through which it declares itself most alarming, is still rarely fatal when early and properly treated..." (1).

Since that time a sizable literature pertaining to delirium has accumulated. It has unfortunately been confounded by the use of multiple synonyms for delirium, non-uniformity in diagnostic criteria and cognitive testing instruments, patient selection bias, and retrospective analyses, which make the interpretation of many studies and observations difficult (2,3). Some of these deficiencies have been rectified in more recent studies by the widespread adoption of standardized criteria for delirium and improved study design.

It is now known that postoperative delirium [POD] is a common complication, associated with significant negative outcomes and that expeditious intervention may reduce both its incidence and severity. Although early detection and treatment are desirable goals, preoperative prediction of those patients at highest risk for POD would allow for the greatest efficacy and direction of nursing and physician resources to those most likely to benefit from interventions. Although a variety of risk factors and several risk assessment models have been identified or constructed, the heterogeneity between groups

studied and the inconsistency of risk factors identified suggest that risk assessment models may require customization dependent on the varying characteristics of different groups of patients. In the surgical context one important difference would be between elective and non-elective patients. To date there have been no studies specifically addressing this issue, and towards that objective this study was performed. In order to clarify and elaborate on this issue, what follows is a discussion of the definition, nature, importance, detection, management, and prediction of POD.

1.2 Diagnostic criteria for Delirium

The DSM-III-R criteria of the American Psychiatric Association [Table 1] are the most widely accepted. Delirium is defined as a transient organic mental syndrome characterized by a global disorder of attention and cognition, a reduced level of consciousness, abnormally increased or decreased psychomotor activity, and a disturbed sleep-wake cycle. Lipowski (4) has criticized the inclusion of "organic" as it implies a restrictive and consistent association of delirium with organic factors for diagnosis, despite the common clinical occurrence of suspected delirium when evidence of specific organic factors are lacking. There is also no consensus on the definition of consciousness so that the term "reduced level of consciousness" is somewhat vague. The main aspects of cognition-thinking, perception, and memory are all disordered to some degree; hence the term "global disorder". The sudden appearance of disturbances of cognition and attention that tend to fluctuate in severity and worsen at night is virtually diagnostic. Although there is no consensus, a reasonable limit to the duration of delirium should be less than one month, after which the presence of dementia can be considered.(5).

1.3 Natural history of Postoperative Delirium [POD]

Although POD may occur at any time in the postoperative period, it most commonly manifests by day 3 to 4, and has usually resolved by day 7(6). The onset may be abrupt or

TABLE 1

DSM-III-R Criteria for Delirium

Reduced ability to maintain attention to external stimuli and to appropriately shift attention to new external stimuli

Disorganized thinking, as indicated by rambling, irrelevant, or incoherent speech

At least two of the following:

- Reduced level of consciousness
- Perceptual disturbances: misinterpretations, illusions, or hallucinations
- Disturbance of sleep-wake cycle with insomnia or daytime sleepiness
- Increased or decreased psychomotor activity
- Disorientation to time, place, or person
- Memory impairment

Clinical features develop over a short period of time and tend to fluctuate over the course of a day

Either one of the following:

- Evidence from the history, physical examination, or laboratory tests of specific organic factor (or factors) judged to be etiologically related to the disturbance
- In the absence of such evidence, an etiologic organic factor can be presumed if the disturbance cannot be accounted for by any non organic mental disorder

From Diagnostic and Statistical Manual, 3rd Edition, Revised. Washington, D.C.: American Psychiatric Association; 1987

gradual, and the patient may appear awake and even hypervigilent or drowsy and obtunded, and both states can appear at different times in the same individual. Lipowski (2) has described three clinical variants.

[1] Hypoalert-Hypoactive where the patient is lethargic and drowsy, answers questions slowly, initiates few actions and is often mistaken for withdrawal or depression.

[2] Hyperalert-Hyperactive where the patient is restless, agitated and speaks loudly as if under pressure of speech, and moves frequently. There may be accompanying autonomic nervous system hyperactivity. This is classically associated with benzodiazepine and ethanol withdrawal.

[3] Mixed type characterized by unpredictable oscillations between hypoactive and hyperactive behavior.

With all types, sensory illusions may appear but delusions are less common. Hallucinations [with incidence of approximately 40% in delirious elders (2)] are most commonly visual, with the rarer auditory hallucinations usually occurring only in the company of visual hallucinations. Partial or complete amnesia for the delirium episode may reflect the lack of memory encoding resulting from the disorder of attention.

The incidence in postoperative elderly patients varies widely [Table 2], reflecting the nature of the patient's illness, differences in mean age, and different methods used in detection and diagnosis of POD. Generally higher rates are seen for orthopedic [44-55%] rather than for general [10-14%] or cardiovascular surgery. The rates are comparable to the reported incidences on medical wards which range from 0.74 to 56% [average of 20-30% at some point during stay in hospital], and critical care units [2-30%], likely reflecting demographic changes that result in older and sicker populations inhabiting medical and surgical wards, and the increased willingness of surgeons to operate on older patients.

TABLE 2

Incidence of Postoperative Delirium in Prospective Studies of Elderly Patients

	POPULATION	METHOD OF DETECTION	INCIDENCE	IDENTIFIED RISK FACTORS
Miller HR, 1981 Br J Psychiat 138: 17-20	Elective surgery patients Age >65 (N=100)	"unspecified cognitive testing days 2 and 4 postoperatively and review of nursing records"	14%	.Medical Complications .Use of morphine
Seymour DG & Pringle R, 1983 Gerontology 29: 8:62:270	General Surgery patients Age >65 (N=258)	Not given	9.7%	.Male sex .Advanced age
Williams MA, et al 1985 Research in Nursing and Health 8:329-337	Hip fracture injury Age >60 (N=170)	Behaviours cited by unit nurses	51.5%	.Advanced age .Poor preoperative functional status .Poor results on preoperative mental status test
Calabrese JR, et al 1987 Cleve Clin J Med 54:29-32	Coronary artery bypass grafting Ages 40 - 75 (N=59)	DSM-III	6.8%	
Berggren D, et al 1987 Anesth Analg 66: 497-504	Hip fracture surgery (N=57)	DSM-III	44%	.History of mental depression .Anticholinergic medications use
Gustafson Y, et al 1988 JAGS 36:525	Hip fracture surgery (N=111)	DSM-III	61.3%	.Advanced age .Pre-existing dementia
Seymour DG, & Vaz PG 1989, Age and Aging 18:316-326	General surgery patients ≥ 66 y/o (N=288)	Decrease in 10 point mental status questionnaire by ≥ 3 points postoperatively	7%	.Poor mobility .Acute medical illness
Rodgers, MP 1989 Intl J Psychiatry in Medicine 19:109-121	Elective hip or knee orthopedic surgery (N=46)	DSM-III	26%	.Treatment with propranolol, scopolamine or fluphenazine
Hiramoto H, 1990 Seishin-Shinkeigaku-Zasshi 92(7):391-410	Mixed surgical procedures Age ≥ 60 (N=27)	Not stated	15.7%	.Length of time under anesthesia .Type of surgical procedure .Preoperative serum albumin, blood loss
Gustafson Y, et al 1991, JAGS 39:655-662	Intervention Group of Hip Fracture Surgery Patients N=103	DSM-III-R criteria	47.6%	.Male sex .Pre-existing dementia
Williams-Russo P, et al 1992, JAGS 40:759-767	Elective bilateral knee replacement (N=60)	DSM-III-R criteria	41%	.Age > 75 .Male sex .History of alcohol use

1.4 Etiology

A cardinal feature of delirium is the loss of attention intensity and/or selectivity. These functions appear to be associated with the brainstem reticular activating system and the neocortex respectively. A long and complex system of cholinergic and monaminergic pathways connect these areas. The monaminergic pathways appear to enhance attentiveness and increase signal-to-noise ratios. Acetylcholine is a neuromodulator that increases neuronal sensitivity to other inputs. The cholinergic nuclei and projections are known to be extremely sensitive to any process impairing cerebral oxidative metabolism (7), and in addition, their function is known to be reduced with increasing age and in primary degenerative dementias such as SDAT [senile dementia Alzheimer type]. To date, cholinergic deficit is the best supported pathological mechanism for delirium. This important role may also explain the commonly [but not universally] reported association between use of anticholinergic medication and the development of POD [as well as delirium in Parkinson disease].

Whatever the underlying mechanisms may be, delirium may be seen in as a response to a heterogeneous collection of metabolic, toxic, environmental, or infectious insults with a relatively homogenous pattern of abnormalities in mental status. The source of the insult is usually outside of the central nervous system (3). Delirium may therefore more commonly herald the onset of physical illness in the elderly than do fever, tachycardia, or pain (2).

A variety of lists and mnemonics exist outlining the commonest causes of POD [Table 3]. Some specific categories are listed below.

[1] Medication interactions, side-effects, and toxicities are a common cause of POD in the elderly (2). Many drugs have been implicated, including anticholinergics, antipsychotics, antidepressants, antiparkinsonian medications, benzodiazepines, and meperidine. Because so many drugs may be culpable and individual reactions are quite idiosyncratic, a prudent caveat is " any drug, at any dose, at any time". In addition, withdrawal from medications is

TABLE 3
Potentially Treatable Causes of Postoperative Delirium

MEDICATION RELATED
- Drug Side Effects
- Drug Interactions
- Drug Toxicities
- Drug or Alcohol Withdrawal states

INFECTIONS
- Pneumonia
- Urinary Tract
- Central Nervous System

CARDIOVASCULAR
- Pulmonary
- Dysrhythmias
- Congestive Heart Failure
- Myocardial Infarction
- Anemia/Hypotension
- Pulmonary Embolism
- Hypercapnia

CEREBROVASCULAR
- Stroke
- Trauma (concussion, contusions, subdural, hematomas)
- Cerebral Anoxia
- Hypertensive Encephalopathy

FLUID AND ELECTROLYTE DISTURBANCES

METABOLIC DISTURBANCES
- Thyroid Dysfunction
- Glucose Disorders
- Acute Thiamine Deficiency
- Uraemia
- Hepatic Dysfunction

FUNCTIONAL FACTORS
- Urinary Retention
- Fecal Impaction
- Sensory Deprivation/Sleep Deprivation/Loss of Visual or Auditory Aids
- Pain
- Immobilization from casts and devices

UNIDENTIFIABLE CAUSES (50% of cases)

an important cause of POD, especially in alcohol, benzodiazepine, and barbiturate users Delirium tremens, the most extreme example, develops 24 to 48 hours after alcohol or barbiturate withdrawal. Wernicke-Korsakoff syndrome is less common, and although classically attended by nystagmus, ataxia, external ophthalmoplegia and amnesia, it may be difficult to diagnosis in the uncooperative, agitated and delirious patient. It is important to note that alcohol withdrawal may occasionally manifest as apathetic behavior.

[2] Infection [and fever], most commonly including systemic, urinary tract or intracranial infections may cause delirium. Pneumonia is the principal systemic cause. In a mixed medical-surgical group of patients, Schor et al. found the presence of symptomatic infection to be predictive of developing delirium. This appeared independent of the degree of fever encountered and roles of cytokines or other bacterial products have been considered (8). Manepalli (9), when studying patients on a psychogeriatric ward, found that 26% of those with delirium had otherwise asymptomatic urinary tract infections and that the delirium cleared with the infections' treatment in 64% of cases. Although the majority of infections causing POD are extracranial in origin, signs of meningismus are less reliably found in elders with meningitis, and a lumbar puncture may be indicated in the febrile, toxic, or delirious elder when no other cause is evident. The increasingly common possibility of HIV infection with encephalopathy should also be considered.

[3] Cerebrovascular accidents that may most commonly present as focal deficits may also manifest as global and diffuse cerebral dysfunction. Uncommonly, unilateral infarction of the calcarine gyrus, mesial temporal lobe, and hippocampus may cause delirium and amnesia (10,11). Bilateral infarction of the calcarine gyri may lead to cortical blindness with denial of visual deficit and prolonged delirium [Anton's syndrome]. Less specific infarction of large areas of the non-dominant hemisphere fronto-parietal areas may produce usually transient but occasionally prolonged delirium. This is much less commonly seen with dominant hemispheric involvement. This observation may reflect right hemispheric dominance in attentional processes, but it is unclear why some patients with

such infarction develop delirium while others develop only focal deficits (3). Prior cerebrovascular events may be a contributing factor, as may be ongoing seizure activity from a cortical focus. Subarachnoid hemorrhage may result in defects of attention and concentration and ultimately stupor and coma. Direct cerebrovascular insults such as subdural hematomas, concussions, contusions, fat embolism, hypertensive encephalopathy, interoperative cerebral anoxia, and toxic-metabolic insults may also produce delirium. Patients suffering from Parkinson disease have a relative risk of 2.8 to 8.1 times that of controls for postoperative delirium and hallucinations (12).

[4] Postoperative hypoxia secondary to atelectasis and analgesia-induced intermittent upper airway obstruction is a common occurrence (13). Falls in oxygen saturation to as low as 65% have been frequently recorded. It is known that cerebral acetylcholine synthesis is especially sensitive to hypoxia. However whether or not hypoxia is an important causative factor or precipitant of POD is not clear. Gustafson et al. (14) were unable to show any statistically significant difference in paO2 values between confused and nonconfused groups of patients, sampled at various times postoperatively. Although the contribution of postoperative anemia was mentioned, there was no formal analysis of oxygen saturation-hemoglobin concentration products and their relationship to the incidence of POD.

[5] Other responsible conditions may include cardiac arrhythmias, pulmonary embolism, atelectasis, and abnormalities in the physical environment [loss of eye glasses or hearing aids, or immobilization with casts or instrumentation].

1.5 Differential Diagnosis of Postoperative Delirium

There are a number of conditions which should be considered in the differential diagnosis of POD. Dementia, in contrast to delirium, has no acute onset, lasts months to years, and has essentially a non-fluctuating and irreversible course. Both conditions share global cognitive dysfunction and they do merge. In addition, less common forms of

dementia such as multi-infarct or trauma-induced dementias may have abrupt onset and fluctuating courses. However, the demented patient characteristically remains alert and aware of her/his environment until in late stages of the disease.

Although epileptic seizures may manifest as a prolonged delirious state, one normally sees features of subtle rhythmic movement of the face, eyes, or jaw, or in the even more rare circumstance of complex partial seizures, staring or other automatisms. Most commonly, this delirium-like state has been reported in patients with past histories of seizures, but de novo presentations in the elderly may be seen (15).

A patient with functional psychosis or "pseudodelirium" tends to have a past history of psychiatric illness, be under the age of forty, commonly demonstrates depressive or manic behavior, has systematized rather than fleeting delusions, auditory rather than visual hallucinations, and lacks the characteristic fluctuation and typical "sundowning" worsening of symptoms. Myoclonus, asterixis and EEG changes tend to be absent, and the patient produces inconsistent results on repetitive cognitive testing (16).

As may be seen in Table 4, in about one half of all of cases, no specific cause is found. These cases likely represent multifactorial causes, where multiple individual pathological perturbations are only of significance enough to cause POD when working in concert.

1.6 Investigation for Causes of POD

Whenever POD is suspected or diagnosed, the etiology should be sought. An historical checklist addressing the commoner causes should be used [Tables 3 and 4]. Similar episodes of delirium in the past may point to a common cause or suggest a previously effective treatment. The content of the delirious patients' speech or complaints, however bizarre, should be analyzed for clues towards underlying causes. One should remember however that the well [let alone delirious] elderly patient may localize pain poorly.

TABLE 4
History, Physical Examination and Laboratory Test Checklist in
The Delirious Elderly Postoperative Patient

A. HISTORY TO INCLUDE:

Duration of delirium
CAM criteria
Type of Surgery, Number of days postoperative
Past history of delirium/proported causes/treatments used

Presence of:

Fever	
Dyspnea	Cough
Orthopnea	Chest discomfort
Urinary retention	Stool incontinence
Urinary incontinence	Diarrhea
Dysuria	Constipation

Fluid intake and output
Weight gain
Recent falls
Medication list

B. PHYSICAL EXAMINATION TO INCLUDE:

Vital signs including incremental change from baseline temperature

Presence of:
Dehydration
Cyanosis
Respiratory distress
Autonomic hyperactivity or instability

Neck stiffness
Pupillary abnormalities

Absence of normal hearing aid or glasses.

Presence of:
Signs of congestive heart failure
Signs of consolidation/pneumonia

Evidence for:
Cerebrovascular accident
Asterixis/Myoclonus

Evidence of:
Trauma

Brief mental status examination.

C. LABORATORY INVESTIGATIONS MAY INCLUDE:

CBC and differential	Serum calcium	Electrocardiogram
Electrolytes, BUN, glucose	Pulse oximetry ± Arterial Blood Gases	Chest x-ray

The physical examination in the lucid elderly patient is confounded by both the presence of non-pathological anomalies which may mimic disease, and the less "classic" or stereotypic manifestations of true disease findings. This is only compounded in the delirious elderly person. As is true in the history taking, a fastidious examination guided by knowledge of the most likely causes should be performed. Normal vital signs or temperature readings do not rule out pathology or infection. One must consider the change from a baseline [preoperative] temperature value rather than an absolute value to determine the presence of a "fever". A rectal examination is necessary to detect fecal impaction, rectal bleeding, or prostatic enlargement [as a cause of bladder distension], and if there are any doubts, in and out catheterization of the bladder with recording of residual volumes should be performed to detect urinary distention.

1.7. Detection of Postoperative Delirium

Detection of POD demands a reasonable index of suspicion, and some type of monitoring for the appearance of DSM-III-R criteria. Most episodes of POD occur in the "silent hours", and a considerable proportion of the more subtle or atypical cases may be missed by only casual assessment by physicians and nursing staff. Williams-Russo et al. (17) noted that physicians and nurses caring for patients missed 50% of the POD detected by the investigators who were performing daily mental status examinations. They felt that cases characterized by combative or agitated behavior were usually noted but that many of those involving quieter forms of perceptual disturbances, disorganized thought, or disorientation [that is, "quiet delirium"] were missed. They also noted that these "missed" episodes were still extremely distressing to patients and families. Morency (18) also noted that attending nurses were reasonably good at detecting disorientation, but they frequently failed to notice other manifestations of delirium such as fluctuating behavior, speech, perceptual and psychomotor disturbances, and disturbed sleep wake cycles. Even minor episodes of POD may be extremely distressing to the patient, and may herald more

significant episodes of POD or underlying medical problems. In addition, earlier intervention increases therapeutic efficacy. These factors underline the importance of sensitive and prompt POD detection as well as the need for more reliable methods for detection. Surveillance and detection are most appropriately performed by nursing staff who spend the most time with the patients [especially nocturnally].

The mental status examination, intimately related to the history, should ideally be brief but adequately address the characteristic interruptions of attention and easy distractibility. These in turn must be distinguished from the unilateral neglect or aphasias of cerebrovascular accidents, distraction due to pain or excess use of analgesia, visual or hearing deficits, and deliberate lack of cooperation (3). Owing to the intermittent and fluctuating course of POD, mental status examinations such as the MMSE may fail to capture the key features of delirium if used alone, and in addition lack the high sensitivity and specificity in delirium and dementia detection when compared to a psychiatrist's judgment (19). For example, Folstein et al. (20) noted a sensitivity of 98% but a specificity of only 57% for dementia in a community based elderly population. Since the MMSE was designed for screening for dementia one would anticipate its performance in delirium screening to be no better.

Liptzin et al.(21), in a study of 325 elders admitted to a general medical ward, found that the DSM-III-R criteria compared favorably with those of DSM-III and ICD-10 in detecting cases of eventually diagnosed delirium. The delirium assessment model of Inouye et al [CAM] [Table 5] is a modification of these criteria and may aid in POD detection. Its format allows for a brief but thorough review of criteria and may be used in such contexts as over the phone discussions with attending nurses to monitor for the manifestations of POD, using a checklist based on the CAM [Appx 6]. It also allows for some quantification of the degree and duration of the POD.

TABLE 5

The Confusion Assessment Method Algorithm (adapted from Inouye et al, 1990)

Feature:

1. ACUTE ONSET AND FLUCTUATING COURSE
   Has there been an acute change in the patients mental status from baseline?
   Does this abnormal behaviour come and go, or increase/decrease in severity?

2. INATTENTION
   Is the patient having difficulty focusing attention, easily distractible or having difficulty in keeping track of what you or others say?

3. DISORGANIZED THINKING
   Is the patient's thinking or conversation disorganized or incoherent?

4. ALTERED LEVEL OF CONSCIOUSNESS
   Is the patient's level of consciousness rated anything other than alert?
   (ie: vigilant, lethargic, stuporous, comatose)

The diagnosis of delirium by CAM requires the presence of features 1 and 2 and either 3 or 4.

Ancillary tests have been proposed to aid in the diagnosis of POD. Electroencephalography may show background slowing, but since this is a pattern seen in dementia as well, the finding is not specific. Bedside recordings of ill patients are compromised by artifact, and the episodic nature of POD makes this test frequently impractical. Similarly, brainstem auditory evoked potentials and P300 signals [an evoked potential possibly more reflective of cognitive activity] may show nonspecific slowing, but this finding may be mimicked by pre-existing dementia.

In conclusion, the diagnosis can be adequately made on clinical grounds with the aid of delirium and mental status assessment models.

1.8. Importance of POD

Although the prognosis may be excellent with expeditious diagnosis and treatment, the onset of POD is a marker for further potential problems and it is associated with important negative outcomes. These include:

[1] Increased length of hospital stay (22-24) [It should be noted that in studies with small sample sizes, a single patient who falls and fractures a limb postoperatively can substantially alter the mean length of stay for their group],

[2] Increased demands on treatment resources,

[3] Poorer post-discharge functional outcome (25),

[4] Attendant increased risks associated with patient interference with postoperative care, and the use of chemical and mechanical restraints,

[5] Increased stress on caregivers, family, and roommates, and,

[6] Possibly higher in-hospital and post-discharge mortality rates (26,27). Rates range from 9.4-65% when both medical and surgical cases are included (16). The high incidence of delirium in the terminal stages of disease may account for these high numbers. The few studies specifically trying to allow for

measures of illness severity suggest that the greater mortality rate may merely be a function of greater illness severity and comorbidity, with delirium having no significant independent effect (26).

The onset of delirium in medical patients has been associated with :

[1] Post-discharge loss of independence and cognitive decline (28),

[2] Increased likelihood of transfer to chronic care facilities (28,29), and

[3] Incomplete recovery to prior cognitive status (30). Approximately one third to one half of patients experiencing POD leave hospital with persisting cognitive impairments (10,20,39), suggesting either preexisting and possibly predisposing dementia or irreversible perioperative cognitive insults.

Postoperative delirium [POD] also appears to be a marker for both concurrent medical illness and possibly underlying dementia, and may be the first clue to such previously unsuspected disorders (31-33). Consequently, its recognition, treatment, and prediction and prevention are important goals to be incorporated into perioperative assessment in the elderly population. General internists and geriatricians are the most appropriate physicians to perform this task.

1.9. Treatment of Postoperative Delirium

Simple algorithms are militated against by multiple etiologies, but some general principles hold. The foundation of effective treatment rests on the prompt recognition, diagnosis, and treatment of underlying causes, and provisional management of agitation and disruptive behaviors. Cognitively impaired elders are at risk for fluid and electrolyte imbalances, aspiration, decubitus ulcers, malnutrition, and other complications of immobility and depressed levels of consciousness, so that these must be tended to as well.

Intervention techniques for prevention or amelioration of POD incidence and severity are effective. Nursing interventions include clarification and orientation to time and place, correction of sensory deficits or inappropriate stimulation, continuity of care, and

recruitment of family members into the orientation process. They are reported to reduce the incidence of POD by 15 to 92%, with length of stays reduced by up to 4 days (23,34,35). Some specifics of conservative treatment measures are listed in Table 6. In addition, Gustafson (14) has outlined physician directed interventions which can dramatically reduce the incidence of POD. [Table 6]

Mechanical restraint devices appear unable to adequately prevent fall-related injuries in the delirious elderly, and there is debate as to whether or not their use, by connotations of entrapment , promote restlessness, agitation, and the fall-related behaviors they aim to prevent (36). The placement of a mattress on the floor, when feasible, is a superior technique, and the use of "boxing glove" hand restraints is more appropriate for prevention of intravenous and urinary catheter tugging.

When symptoms of POD fail to respond to conservative measures and the treatment of underlying disorders, pharmacological intervention may be tried. Before any pharmacotherapy is commenced, one should identify target symptoms such as hallucinations, delusions, and severe agitation, in order to define and assess therapeutic efficacy and endpoints. One should also remember that in elders, there are increased risks for drug side-effects, toxicity and drug interactions.

Because nurses spend the most time with patients, especially during the "silent hours" in which the incidence of POD is greatest, they are in the optimal position for early detection and treatment of POD. Unfortunately, although effective, such nursing intervention techniques are time and labour intensive, prohibiting their widespread "prophylactic" implementation. In addition, physician directed interventions are most effective if organized preoperatively.

The incidence of POD, its negative impact on postoperative outcomes, the recent improvements in methods for its detection, and the demonstrated efficacy of early detection and treatment, justify vigorous attempts to implement preventative measures and surveillance for POD as early as possible perioperatively. The time and resource costs of

TABLE 6

Interventions Used to Reduce the Incidence and Severity of Postoperative Delirium in Elderly Hip Fracture Surgical Repair Patients

NURSING INTERVENTIONS (9) (30)

1. Approach the patient with a friendly and quiet manner.
2. Bring familiar objects from the patient's home, and use the patient's favourite words or expressions in conversations, requests or explanations.
3. Place time pieces and calendars within easy viewing of the patient.
4. Correct deficits in sensorium (replace glasses or hearing aids).
5. Place the agitated patient in a quiet environment, or the lethargic patient in a more stimulating environment (for example by the nurse's station).
6. Attempt to maintain familiar routines of eating, sleeping, and elimination.
7. Use adult diapers rather than poorly tolerated foley catheters to manage incontinence.
8. Avoid the use of physical restraints.
9. Reduce immobility and pain.
10. Recruit the assistance of relatives, and extend visiting hours for the closest kin.

PHYSICIAN INTERVENTIONS (28)

1. Perform preoperative medical assessment and correct problems if possible.
2. Minimize delays until surgery.
3. Avoid intra-operative hypotension[1]
4. Administer postoperative supplemental oxygen to avoid hypoxia[2]
5. Administer postoperative deep venous thrombosis prophylaxis
6. Perform prompt assessment and treatment of any postoperative delirium

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[1] Intraoperative hypotension has been defined as a drop in systolic blood pressure by greater than or equal to 30% of preoperative value or to less than 80 mm Hg.

[2] Supplemental oxygen given on day of surgery and continued to include the first postoperative day.

such intervention and surveillance make universal implementation impractical. *Identification of high risk groups is therefore desirable.*

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Chapter Two. Preoperative Prediction of Postoperative Delirium

2.1 Identified risk factors

An number of studies have attempted to identify predictive or predisposing factors. The small sample sizes of many studies and the multifactorial nature of POD make it difficult to separate causal from merely correlational relationships, but a number of factors have been identified. These include male gender (1,2), and increasing age (1-4), although the latter may merely reflect a greater likelihood for poorer medical, functional, or cognitive status.

Preoperative medical, functional and cognitive status are likely important predictors and have in turn strong correlations with each other. Fields et al.(5) looked at the prevalence of cognitive impairment in admissions to medical services and found that demented [defined as an MMSE score less than 24] patients were generally older, more ill, less physiologically stable, and more susceptible to complications than were their non-demented counterparts. Williams et al.(3) observed that orthopedic fracture repair patients with lower preoperative physical activity levels were more likely to develop POD. Rockwood (6) noted that patients developing confusion on a general medical ward tended to be older, more ill, more dependent as measured by the Katz ADL Index, and that 66% of those presenting with a prior history of dementia developed confusion. Schor et al.(2) in a mixed surgical-medical patient group [in which the surgical patients comprised 49% of the total] noted cognitive impairment to be an independent predictor of post-admission delirium. Intuitively one would also expect increased risk for POD in patients suffering dementia, but results of postoperative studies do not consistently demonstrate this relationship (1,4). Reasons for this may include the shortfalls in the mental status screening tests used [which all have suboptimal sensitivities and specificities], the confounders of variable educational levels, the pain, stresses and narcotic analgesics encountered by the

preoperative fracture patient, and the practical time limits imposed on the duration of testing.

The potential importance of decreased functional status and cognitive impairment in POD prediction is highlighted by the prevalence of these factors in the elderly population. Ten percent of elders more than 75 years of age report major limitations in their daily activity (7), and studies of dementia prevalence show 10% of elders over 65 to suffer from it. This percentage increases up to 47.2% for those over 80 years of age (8,9), and may be even higher in the institutionalized (10). Alzheimer-type dementia comprises approximately 80% of these cases (8). Consequently a brief but more sensitive and specific cognitive impairment screening tool would be invaluable for preoperative POD prediction.

Teng and Chui (11) have proposed a revision of the MMSE, "the 3MS", which improves on sensitivity and specificity by the addition of four items and allows for more refined scoring. This revised screening test has been used in the Canadian Study on Health and Aging and will undergo evaluation with other data. Sui (12) has demonstrated that the probability of dementia is greatly reduced when either normal serial sevens, 3 item recall, or normal clock drawing test results are obtained. Only scores less than 20 on the MMSE significantly increase the likelihood of dementia. Sunderland et al.(13) have shown that the clock drawing test is a reliable indicator of visuo-spatial disability in SDAT and correlates well with other measures of dementia severity. It has the obvious advantage of being brief and therefore is a practical addition to preoperative assessment.

Implicated medications include antidepressants, and psychoactive medications, as well as a history of sedative or alcohol abuse with its attendant risk for withdrawal. Although there are conflicting results, a number of studies have implicated anticholinergic medications (2,4,14).

Although the type of surgery undertaken appears to influence the incidence of POD [with higher rates in orthopedic and cardiovascular versus general surgery patients], the

type or duration of anesthesia likely has little importance, with similar incidence rates seen with general or local epidural block anesthesia (15,16). Williams-Russo et al.(17), in a small study, were unable to demonstrate any difference in rates of POD between different types of postoperative analgesia.

Early postoperative hypoxia (14) and hypotension (4) may be important contributors to POD, and interventions directed towards their elimination appear to reduce the incidence and severity of POD (1).

Visual and hearing impairment, which affect as many as 40% of hospitalized elders, may be important in studies of delirium development in medical patients (18), but to date no study has demonstrated increased incidence of POD over non-sensory impaired elders.

2.2. Ancillary methods of Prediction

Owing to poor diagnostic ability, inconvenience, and high cost, diagnostic imaging techniques have formerly been impractical methods for screening dementia. In moderately advanced SDAT, positron emission tomography [PET] can detect a characteristic pattern of decreased glucose metabolism and regional hypoperfusion in posterior parietal lobes and adjacent temporal and occipital cortex, superimposed on globally reduced cerebral blood flow (19). Although an extensive literature on brain-behavior-imaging does not exist for single positron emission computerized tomography [SPECT], recent advances with improved resolution and the development of new isotopes promise to bring many of the diagnostic abilities of positron emission tomography to an accessible level through the use of SPECT. SPECT scanners use standard nuclear medicine gamma cameras which have been modified to rotate 360 degrees, and less expensive, more readily available radioactive tracers like radioactive iodine and Tc99. Studies have reported PET and SPECT discrimination from normal of between 25-100%, depending on the severity of the dementia (20). At the University of Alberta considerable experience has be attained with the use of SPECT scanning in assessment of dementia. McEwan and Katz have

developed a 3-D region of interest model which divides the brain into 7 contiguous but non-overlapping zones in each hemisphere. Single coronal, axial, and saggital regions are displayed and automatically overlaid, and uptake is expressed as a percentage of total cerebral-cerebellar uptake.

A typical protocol for a SPECT scan involves the subject resting with eyes closed for 20 minutes. This is followed by intravenous injection of a radionuclide such as HMPAO [Tc99 hexamethylpropyleneamine oxime], a neural and lipid soluble amine which crosses the blood-brain barrier. Its intracerebral distribution correlates well with cerebral blood flow. Acquisition of images, which may be done up to several hours after injection, takes approximately 20-30 minutes. The cost for the scan is approximately $250.00. The practicality of this technique in terms of time and cost makes it a consideration for dementia screening and consequently delirium risk assessment.

2.3. Development of Delirium Risk Assessment Models

Looking at risk profiles rather than single factors is important, for although single problems or conditions may cause no disability or increased risk, significance may be gained by combination or synergism with other concomitant conditions. Several investigators have identified sets of risk factors for delirium prediction based on the study of medical or mixed medical-surgical groups (2,18), but it is uncertain whether such results are generalizable to the perioperative setting. In addition, the results of previous surgical patient-based studies demonstrate a lack of consistency, with different studies identifying different combinations of risk factors. The reasons for this may be methodological, for example, related to methods of detection of delirium or proposed risk factors like dementia. It is also possible that these differences reflect different preoperative medical, functional and cognitive profiles, [and consequently different prevalences of risk factors], in the patients of various populations studied. If so, any resource efficient risk assessment model must be derived and applied with consideration

of these different profiles in order to avoid its utilization in settings where the pretest probability of its identified risk factors are inappropriately low. For example, the octogenarian female with a fractured hip may be better served by a different POD risk prediction model than the sixty year old osteoarthritic male undergoing elective hip surgery.

This principle is supported in part by Gustafson's study which showed physician directed perioperative intervention techniques not only reduced the incidence of POD with respect to the control group, but also changed the risk factor profile from that of the control group. By removing or changing certain patient characteristics [such as number of uncorrected medical problems], the relative importance of various potential risk factors may be altered. It could be further argued that the thoroughly assessed and medically attended patient undergoing elective hip surgery also has as different a patient characteristic profile and therefore also requires a different predictive model.

2.4. Studying Elective Orthopedic Patient Groups

Previous studies have been restricted to elders undergoing emergency fracture repair or bilateral knee replacement; procedures known to have high incidences of POD. To date, no elective population of patients undergoing hip or unilateral knee surgery has been studied. There are reasons for and advantages to doing so:

[1] Elective hip or unilateral knee surgeries are common procedures in the elderly.

[2] History taking, physical examinations, and medical problems may be better performed and assessed preoperatively.

[3] More thorough preoperative mental and functional status assessments can be made and more time is available to reliably perform and compare screening instruments.

[4] Presentation to surgery, and the nature and delivery of anesthesia, postoperative analgesics, nursing care and surveillance can be more standardized, coordinated and rigorous.

[5] Medical problems and risk factors are more easily identified and rectified in a preoperative assessment clinic.

[6] The confounding potentials of fracture related pain, stress, and analgesia on physical, mental, and functional assessment as well as co-morbid disease [which may have led to the fall] may be avoided, both by absence of the fracture and by pre-operative risk reduction measures.

The above, easily and adequately performed in preadmissions clinics, allow for more precise and thorough retrospective analyses of individual potential POD risk factors and construction of models for assessing preoperative risk for POD in elective patients. In addition, the study of a cohort of patients presenting over the same time period for emergency hip fracture repair would allow for comparison of differences in patient characteristics and risk profiles both between these groups and with the literature.

Consequently the following study was performed. Its objectives were:

[1] To compare the incidence and severity of POD in elderly patients attending a preadmissions clinic and undergoing elective orthopedic surgery with that of non-elective fracture repair groups (both those presenting to the same institution and those reported in the literature.)

[2] To identify and compare potential preoperative risk factors for POD in the elective and non-elective groups.

[3] To assess the utility of SPECT scanning in the detection of delirium.

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Chapter Three. Study Methods and Results

3.A Methods

3.A1 Consent

Approval was obtained from the UAH Faculty of Medicine Research Ethics Board prior to initiation of the study.[Appx 2]

3.A2. Patient Enrollment and Protocols

Between September 1 and June 20 1993 all patients attending a University hospital orthopedics preadmission clinic for medical assessment prior to elective hip or knee replacement surgery were approached consecutively to obtain consent for inclusion into the study. Enrollment was limited to the first three acceptances per day. Exclusion criteria included reaching the daily quota, refusal, previous enrollment, age less than 60, or inability to speak English. Patients under age 60 were excluded both to conform to previous study protocols and to avoid problems incurred by screening populations in which the pretest probability of POD is low (1,2). Enrolled patients underwent same-day screening including modified history taking and physical examination which included the recommendations of the ACP Committee on Aging for functional disability (3), and the Hachinski Ischemic Scale (4), bloodwork, chest xrays and ECG tracings, Folstein's Mini-Mental Status examination, a clock drawing test (5), ADL and IADL scores, and HMPAO SPECT brain scanning. SPECT scanning was done by the protocol mentioned previously, giving 13.5 mCi of injected HMPAO intravenously to patients who had rested with eyes closed in a darkened room for 20 minutes, followed by 20 minutes of image acquisition time.

All information was collated on standard forms [Appx 3,4,5, and 6]. The physician responsible for following patients postoperatively was blinded to results of mental and functional status examinations and SPECT scanning until after patients had been discharged from hospital. If significant medical problems were identified, surgery was

postponed until the patients problems had been resolved. There were no dropouts from the study for this reason.

Patients were followed from 8 hours post-operatively until the end of the fourth post-operative day. Surveillance included daily visits and twice daily [630 and 2230 hrs] telephone interviews with attending nurses using a modified CAM questionnaire [Appx 1], repeated MMSE and clock drawing tests on the first and fourth postoperative days, and a repeat SPECT brain scan on the 3-5 postoperative day. In the event of CAM criteria being fulfilled, further assessment included a history and physical examination, MMSE, and pertinent laboratory investigations, done as quickly as possible [Appx 7]. In all cases, an attempt to determine the cause(s) of the POD was made and recommendations for treatment or intervention were provided.

3.A3. Chart reviews

After discharge all charts were reviewed and information including length of stay, type and duration of anesthesia, operative and postoperative problems was collated [Table 7]. A medical problem in both groups was considered "significant" if it was recognized as an important factor in the assessment of patient functional or perioperative risk status.
In addition,charts of all patients aged 60 or greater, undergoing non-elective surgery for hip or knee fractures at the same hospital during the same period (September1992- June 1993) were reviewed . None of these patients had attended the elective preadmission clinics. Criteria for determining development of delirium included recorded physician diagnoses of POD, or documentation of behavior consistent with POD in nursing or progress notes [eg: agitation, disorientation, and inattention]. POD was considered to be severe if lasting 5 or more days, if involving disruption to the patients' care, or if requiring nursing or physician intervention. Information including specifics of preoperative medical, functional and cognitive status, type and timing of surgery, anesthesia, and analgesia, and postoperative course was recorded. [Table 7]

TABLE 7

Data Examined from Elective & Emergency Fracture Repair Patients' Charts

A. PREOPERATIVE

Gender
Age
Residence Prior to Admission
Number of Significant Preoperative Medical Problems
Number of Kind of Preoperative Medications
Prior History of Postoperative Delirium
Prior History of Dementia
Preoperative Delirium

B. INTRA-OPERATIVE

Type of Surgery
Duration of Surgery
Type and Duration of Anesthesia
Intra-operative Hypotension
Intra-operative Estimated Blood Loss

C. POSTOPERATIVE

Presence or Absence of Postoperative Delirium
Cause(s) of Delirium if known
Baseline and Lowest Recorded Hemoglobin Values
Postoperative Hypoxia
Number and Kind of Medications used
Type and Duration of Analgesia
Foley Catheter Insertion and Date of Removal

3.A4. Study Participant Roles

All elective patient histories, physical examinations, in-hospital telephone interviews and in-person assessments and all chart reviews on fracture repair surgery patients were performed by the investigator. All ADL/IADL, MMSE, and clock drawing assessments were administered by the same trained assistant. Clock drawing results were scored independently by the investigator and a geriatrician, using the system outlined in Appx 8. In the infrequent event of discordance in scores for a given clock, the higher score was accepted. A score of 6 or less was considered abnormal. All patients in the study [both elective and fracture-repair], underwent surgery with the same orthopedic and anesthesia groups, were admitted to the same three orthopedics wards, and were cared for by the same group of nurses. All SPECT brain scans were performed by the same team and reviewed by the same two nuclear medicine physicians.These physicians were blinded to other results until after their analysis had been completed.

3.A5. Statistical Analysis

Statistical analysis was performed on data from both the elective and hip fracture groups, using either t-Tests [for continuous variables] or chi-square /Fisher's Two-tailed Tests [for discrete variables]. Univariate analysis was performed first, both to demonstrate the relationship between each individual factor and outcome, and to screen for the most probable predictors prior to entry into a logistic model, in order to reduce the potential for colinearity between factors. From such univariate analyses in the elective group, factors found to have significant or near significant p-values were selected for additional stepwise multivariate logistic regression analysis to determine best fit to a logistic model. This form of logistic analysis was chosen because the results of measured outcome [POD] were discrete rather than continuous. Consequently, rather than least squares regression r2 values, correctness of prediction, sensitivity, and specificity were used as estimates of predictors' contributions and model power.

3B. Results

3B.1 Enrollment

A total of 91 patients were approached for consent. Six patients refused, 1 was excluded owing to an inability to understand the consent process, 4 dropped out during the study, and 80 completed the study in its entirety. The nurses' telephone CAM interview had comparable sensitivity to the investigator's subsequent assessment of the patient. The CAM interview detected 13 of the 14 cases of POD ultimately diagnosed, and generated no false positive diagnoses.

3B.2 Incidence, onset, and duration of POD

In the elective surgery group 17.5% of postoperative patients fulfilled the CAM criteria for POD. Less than half of these were seriously delirious (7.5%). The mean date of onset of the delirium was 0.84 days postoperatively (range 0-5 days) and the mean duration 1.56 days (range 0.05-4 days). All cases recovered before discharge and in 36% of cases, one or more precipitating causes was identified. Factors were deemed causal if their amelioration or removal led to prompt recovery from the POD. A total of 66 charts were obtained from the medical records, representing the admissions of patients aged 60 or greater admitted for surgical repair of fractured hips during the period of September 1, 1992 to June 21 1993. Of these patients, 50% developed POD, and seriously confused patients made up 34.3% of the total group.

3B.3 Positive Results and Comparisons within Elective Group [Table 8]

In the elective group, male gender, use of analgesia other than PCA Morphine [patient-controlled analgesia-morphine][Appx 9], and abnormal preoperative clock drawing tests were significantly associated with postoperative delirium when analyzed singularly. The type of operation [hip versus knee surgery] showed a trend towards increasing incidence of POD with hip surgery. Significant but obviously non-causal

TABLE 8

A. FACTORS ASSOCIATED WITH INCREASED INCIDENCE OF POD IN ELECTIVE GROUP

FACTOR	UNIVARIATE ANALYSIS SIGNIFICANCE (p value)	STEPWISE MULTIVARIATE LOGISTIC REGRESSION ANALYSIS SIGNIFICANCE (p value for Wald Chi square)
Male Gender	0.0001	0.0095
Abnormal Preoperative Clock Test	0.0087	0.0096
Postoperative Analgesia Other Than PCA Morphine*	0.0423	0.1000
Hip Versus Knee Replacement Surgery	0.1654	0.065
Abnormal MMSE on 4th Postoperative Day	0.0058	
Abnormal Clock Test on 4th Postoperative Day	0.008	

B. FACTORS NOT ASSOCIATED WITH INCREASED INCIDENCE OF POD IN ELECTIVE GROUP

FACTOR	SIGNIFICANCE (p value)
Age	0.986
Number of Medical Problems	0.7829
Intra-operative Hypotension	0.703
General Versus Regional Anesthesia	0.763
Postoperative Hypoxia	1.000

* PCA morphine = patient controlled morphine analgesia administration using metered intravenous delivery device

C. CONTRIBUTION OF FACTORS TO MODEL

FACTOR ADDED	SENSITIVITY	SPECIFICITY	CORRECT PREDICTION (%)
Abnormal Clock Test	91.1	0.0	70.7
Male Gender	97.8	30.8	82.8

TABLE 9
Comparison of Incidence of POD Between Elective and Fracture Repair Groups

GROUP	INCIDENCE OF POD TOTAL	SEVERE†
UAH Elective Group	17.5%	7.5%
UAH Fracture Repair Group	50%	34.3%
Significant Difference (Fracture-Elective)	p<0.0001	p<0.0001
Gustafson's Control Group	61.3%	29.7%
Williams' Control Group	51.5%	16.0%
Gustafson's Intervention Group	47.6%	6.8%
Williams' Intervention Group	43.9%	8.8%

†POD is defined as "severe" if causing severe caring problems (pulling on tubes or intravenous lines or clambering over bedrails, etc.) or is prolonged (>7 days).

associations were also seen between abnormal scores on clock drawing and MMSE on the fourth post-operative day.

Stepwise multivariate logistic regression on these variables showed male gender, and abnormal clock test drawing to be the most highly predictive. These two factors were predictive of delirium in 82.8% of cases, 97.8% sensitivity and 30.8% specificity. The type of operation demonstrated only borderline statistical significance as a predictor of POD.

3B.4 Negative Results and Comparisons within the Elective Group [Table 8]

In the elective surgery group, no significant relationship was found between POD and the following independent variables:

Age, education, non-English as first language, activity of daily living scores [ADL and IADL], history of cerebrovascular accidents, smoking, constipation, anemia, diabetes, hypertension, cardiac disease, number of medications used preoperatively, number of preoperative medical problems, number of other joints impaired, number of prior surgeries, history of alcoholism or positive CAGE score, history of depression, getting lost, prior POD, frequent falls, or nocturnal confusion, urinary or fecal incontinence, hearing or visual acuity deficits, mobility scores, presence of primative reflexes, preoperative or day 1 MMSE scores, preoperative hemoglobin, electrolyte, serum glucose, blood urea nitrogen, chest xray, or EKG abnormalities, type and length of anesthesia, intraoperative or postoperative hypoxia or hypotension, estimated intraoperative blood loss or nadir in postoperative hemoglobin values, or postoperative foley catheter use.

SPECT scanning results were incompletely analyzed at the time of writing owing to unexpected problems with analytical software. However, initial assessment of the scanning results failed to reveal any significant differences between the elective POD and NPOD groups pre-operatively and did not show development of any focal abnormalities post-operatively in the POD group.

3B.5 Positive Results and Comparisons between Elective surgery and Fracture Repair groups [Tables 9 and 10]

(a) The incidence [17.5%] and severity [7.5%] of POD was significantly lower in the elective surgery group as compared to the fracture repair group [50% / 34.3%], with the latter's incidence comparable to that reported in the literature [61.3-41% / 30-6.8%].
(b) No significant differences or asymmetries were seen in overall gender ratios between or within elective surgery and fracture repair groups. However, a major difference in gender ratios exists between the elective and fracture POD subgroups, with a significantly higher proportion of males developing POD in the elective group. This gender ratio does not hold for seriously confused subgroups in either elective or fracture subgroups, perhaps owing to the smaller sample sizes involved.
(c) Significant differences exist in ages between the two groups, with the fracture group being comprised of older patients.
(d) Significantly more patients in the fracture group come from chronic care facilities [CCFs].
(e) Both pre-existing dementia and preoperative delirium are significantly more common in the fracture repair group. No cases of preoperative delirium were graded as severe and all worsened if occurring postoperatively. Virtually all patients that were delirious preoperatively were delirious postoperatively.

No significant differences exist as to the type of anesthetic used and incidence of POD within fracture or elective surgery groups, or between the groups. The elective group had general anesthesia more often than did the fracture group [62.5% versus 47.7%] but this was only a trend [$p = 0.093$].

TABLE 10

Comparison of Elective and Fracture Repair Groups

A. DIFFERENCES

FACTOR	ELECTIVE GROUP	EMERGENCY FRACTURE REPAIR GROUP	SIGNIFICANCE OF DIFFERENCE (p value)
Mean Age	71.19	78.26	<0.0001
Age >80 (%)	8.75	46.96	<0.0001
Pre-admission Residence in Chronic Care Facility (%)	0	19.7	0.0085
Pre-admission History of Dementia (%)	0	16.6	0.0027
Preoperative Delirium (%)	0	16.6	0.0027
Postoperative Analgesia PCA Morphine (%)*	73.7	4.5	<0.0001
Type of Surgery (% Hip)**	61.2	100	<0.0001
Mean Duration of Surgery (minutes)	172.81	119.47	<0.0001***

B. NO SIGNIFICANT DIFFERENCE

FACTOR	ELECTIVE GROUP	EMERGENCY FRACTURE REPAIR GROUP	SIGNIFICANCE OF DIFFERENCE (p value)
Gender (% male)	46.3	34.85	0.1797
Mean Number of Preoperative Medical Problems	2.29	2.55	0.3313
General Versus Regional Anesthesia (% General)	62.5	47.7	0.093
Mean Estimated Intra-operative Blood Loss	266.7	226.28	0.141
Intra-operative Hypotension (%)	17.5	21.2	0.674

* Patient-controlled analgesia protocol using morphine.
** Hip = Total Hip Replacement, Austin-Moore, Dynamic Hip Screw.
*** Negative correlation with decreasing POD incidence with increasing surgery duration.

(f) The use of patient controlled morphine analgesia [PCA morphine] was associated with a lesser risk of POD in the elective group. In addition, PCA morphine was used far more frequently than intramuscular [IM] morphine in the elective versus fracture repair group.
(g) All fracture repair patients underwent some form of hip surgery, compared to only 61.25% of elective group, [supporting the trend seen within the elective group towards increased POD with hip surgery].

3B.6 Positive Results and Comparisons Within the Fracture Repair Group [Table 11]

Significant differences exist between the POD and Non-POD subgroups. On average, patients who developed POD were older, had more pre-existing medical problems, were more commonly delirious pre-operatively, had a higher incidence of preoperative dementia, and more commonly resided in a chronic care facility prior to admission.

3B.7 Negative results and comparisons within the Fracture Group [Table 11]

There was no significant difference between the delirious and nondelerious groups in duration of delay before surgery, intraoperative estimated blood loss [negative trend], or postoperative hypoxia [negative trend]. Although postoperative hypoxia was more common in the fracture group, in the majority [89%] of cases it involved patients who did not develop POD.

3B.8 Negative results and comparisons between the Elective and Fracture Groups [Table 10]

In comparison between elective and hip fracture surgery groups there were no significant differences in the number of preoperative medications used, duration of surgery [negative trend only], intraoperative estimated blood loss, incidence and duration of intraoperative hypotension, or incidence of postoperative hypoxia. Comparisons of mean hospital length of stay [LOS] and percentage of hospital stays greater than 7 or 14 days

TABLE 11

Comparison of POD and Non-POD Subgroups of Fracture Repair Group

A. SIGNIFICANT DIFFERENCES

PREDICTOR	POD GROUP	NON-POD GROUP	SIGNIFICANCE OF DIFFERENCE (p value)
Mean Age	81.56	75.15	0.0034
Age Greater Than 80 (%)	68.75	20.58	0.0002
Mean Number of Preoperative Medical Problems	3.22	1.91	0.0013
Preoperative Residence in Chronic Care Facility (%)	37.5	2.9	0.0004
Pre-admission History of Dementia (%)	31.2	2.9	0.0024
Preoperative Delirium (%)	31.2	3.0	0.0027

B. NO SIGNIFICANT DIFFERENCES

PREDICTOR	POD GROUP	NON-POD GROUP	SIGNIFICANCE OF DIFFERENCE (p value)
Proportion Male Gender	31.25	40.6	0.6116
Mean Duration of Surgery (minutes)	117.34	112.47	0.5991
Mean Delay in Surgery (hours)	31.07	38.77	0.5429
General Anesthesia Versus Regional (%)	45.2	50.0	0.805
Intra-operative Hypotension (%)	28.12	14.70	0.2344
Mean Intra-operative Estimated Blood Loss	266.67	226.68	0.1419
Postoperative Hypoxia (%)	7.7	9.2	0.2317
Postoperative Analgesia (% PCA morphine)	0	8.8	0.239

C. SUBSET ANALYSES OF DIFFERENCES IN MEAN NUMBER OF PREOPERATIVE MEDICAL PROBLEMS

GROUPS COMPARED	MEAN DIFFERENCE	SIGNIFICANCE OF DIFFERENCE (p value)
Fracture (total) - Elective total	0.26	0.3313
Elective POD - Elective NPOD	0.12	0.7829
Fracture POD - Fracture NPOD	1.31	0.0013
Fracture POD - Elective Total	0.93	0.0049

POD = Postoperative delirium
NPOD = No postoperative delirium

within and between elective and fracture groups were made. A trend was seen with increasing length of stay from elective non-delirious to fracture repair delirious groups [Table 12]. However on univariate analysis, there were significant differences in LOS seen only between the elective and fracture NPOD groups.

TABLE 12

A. COMPARISON OF HOSPITAL LENGTH OF STAY (LOS)

GROUP	MEAN LENGTH OF STAY (days)	% PATIENTS LOS >14 DAYS
Elective NPOD	8.98	6.0
Fracture NPOD	9.50	23.5
Elective POD	10.71	7.0
Fracture POD	15.84	37.5

B. SIGNIFICANCE OF DIFFERENCE IN LENGTH OF STAY (LOS) BETWEEN GROUPS

DIFFERENCE	% STAY >7 DAYS (p value)	% STAY >14 DAYS (p value)
NPOD Elective - POD Elective	0.172	1.000
NPOD Fracture - POD Fracture	0.198	0.286
NPOD Fracture - NPOD Elective	0.170	0.020
POD Fracture - POD Elective	0.240	0.072

NPOD = No postoperative delirium
POD = Postoperative delirium

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Chapter Four. Discussion

Although this study was performed in a tertiary care hospital setting, the referral base of patients, and nature and indications for surgery conformed to that of a community hospital, making a strong referral bias unlikely. Only 11.7% of those approached for consent and 4.8% of the inception cohort did not complete the study. This value is well within the 20% limit suggested by the McMaster criteria .

The modified CAM telephone interview system appeared to be a practical and sensitive method for surveillance of POD. The incidence and severity of detected POD in this elective population was significantly less than that detected in the concurrent fracture repair group or in fracture groups reported in the literature. Although POD cases may have be missed in the elective study, a conservative estimate was more likely to have occurred in the comparison fracture group, given the limitations of retrospective chart review for POD criteria and the well documented under-detection and under-reporting of POD by caregivers (1,2). The lower incidence of POD in the elective group also probably reflects both the absence of risk factors noted in previous studies and the presence of other factors thought to reduce risk. Such factors [cited in Gustafson's intervention study (3)] incorporated in this study's elective group included preoperative assessment and correction of medical disorders, thromboembolic prophylaxis, avoidance of surgery delay and intraoperative hypotension, postoperative oxygen therapy, control of postoperative immobility and pain, and thorough postoperative surveillance and prompt treatment of POD. Intraoperative hypotension, duration of surgery, postoperative hypoxia and anesthetic type, have shown, at best, only trends in previous studies, and were not significantly different between elective POD and NonPOD groups. The noted incidence of severe confusion in this group is comparable to Gustafson's intervention group [7.5% versus 6.8%].

Major differences were seen in comparisons of elective and fracture group characteristics. Although the groups were equally matched for gender composition, many more men than women became delirious in the elective group. Proportionally, there were no differences in male and female contributions to the fracture POD group. Interestingly, these findings parallel the results of Gustafson's intervention and control groups (3). The mean age was significantly higher in the fracture repair group, as were the incidences of pre-existing dementia, preoperative confusion, and preadmission residence in a chronic care facility (CCF). Although no formal estimations of preoperative disease severity were performed, as a whole the fracture repair group had more severe but not more numerous medical problems. However, comparison of subsets shows that the fracture repair POD group had significantly more pre-existing medical problems than did either the fracture repair NPOD or total elective groups [Table 11 C]. This illustrates the relationship between impaired medical status and increased incidence found elsewhere in the literature These findings of considerable differences in preoperative functional, mental, and medical status between the elective and fracture groups may underlie the differences in POD incidence. A lack of measurable difference in such medical and functional status markers within the POD and NonPOD subsets of the elective group may reflect the inability of these tests to discriminate between gradations of relatively good status in this "high end group".

Within the elective group, patients who experienced POD were significantly more likely to have been male, and have had scores less than 6 on the clock test. Near significance on 2-tailed multivariate analysis was noted in patients having undergone hip versus knee surgery, and given previously reported lower incidence of POD [14%] in studies of unilateral hip surgery, this may be an important factor (1). It is noteworthy that these significant predictors, whose independent effects are confirmed in multivariate analysis, are not preventable or mutable and likely represent a "baseline" risk profile.

A trend on univariate analysis towards increased use of PCA morphine (over other forms of postoperative analgesia) and decreased POD incidence was not substantiated on multivariate analysis.

Although analysis of the SPECT scan data is incomplete, a preliminary lack of difference between POD and NPOD elective groups results before and after surgery does not suggest a high degree of utility in the preoperative screening for cognitive dysfunction or POD risk. Definitive assessment must await more detailed region of interest analysis of the data.

Inferences to other identifiable risk factors for POD, based on comparisons between the elective and fracture groups, are weakened by the potentially confounding methods of retrospective chart review. However, significant differences in measures of cognitive or functional status such as pre-existing dementia, preoperative delirium, residence in a CCF, as well as in age [older] suggest that these are also predictors of increased risk for POD. The trend towards significantly less POD with the use of PCA morphine postoperative analgesia, seen in the elective group, was not supported by any significant difference in use between the POD and NPOD fracture repair groups. There were, however, only small number of patients using PCA morphine in both fracture subgroups. Similarly, the possible relationship between increasing POD with decreasing use of general anesthetic in the fracture group is weakened by the lack of difference in anesthetic use between elective POD and NonPOD groups, and by a lack of any significant relationship reported elsewhere in the literature (4,5). Thus the observed infrequent use of general anesthetic and PCA morphine in the fracture group may merely reflect anesthetists' perceptions of poorer preoperative risk, medical or cognitive status in this group of patients.

The striking differences in incidence of various risk factors between the elective and non-elective group parallel those of previous intervention studies and reinforce the importance of assessing risk in the content of the particular group's medical, cognitive, and functional characteristics. Therefore two models can be constructed for POD prediction,

depending on whether the proposed orthopedic procedure is elective or non-elective fracture-repair . For elective patients, preoperative assessment in preadmission clinics with enough lead time for appropriate medical intervention is advocated. Assessment should include gender, administration and scoring of performance on the clock test, and possibly the type of surgery planned. Male gender, and a clock score of 6 or less most strongly suggest increased risk for POD. For emergency fracture-repair patients, assessments positive for age over 80, past history of dementia, preoperative residence in a CCF, numerous significant medical problems, and evidence of pre-operative delirium indicate a higher risk for POD. Intuitively, poor performance on a clock test should also be predictive and more practical to perform in this setting than any other cognitive screening tests. Because intervention is effective both for prevention and amelioration of POD, identified "high risk" patients can be earmarked for both nursing surveillance using the CAM protocol, and preventative nursing intervention techniques. If "breakthrough" POD occurs, prompt investigation and treatment of any underlying causes should be done. Clearly these models should be tested by prospective trials in which patients assessed for risk prior to surgery are followed postoperatively for documentation of incidence and severity of POD. Once validated, such screening, directed surveillance, and intervention measures can be incorporated into care guidelines.

It is reasonable to assume that decreased incidence and severity of POD would translate into resource savings. In this study, the only measurement of POD impact on outcome that was studied was length of stay. Although a trend was seen suggesting increased length of stay in the fracture repair group, a lack of significant differences on univariate analyses was seen in all but between the elective and fracture repair NPOD groups. This suggests that the trend is more related to differences other than POD incidence between the elective and fracture repair groups [Table 12]. However, significant differences may have been masked by the generally mild nature of POD in the

elective group and early transfer to local hospitals of still delirious patients in the fracture group.

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5. APPENDICES

APPENDIX 1

Assessment of Postoperative Confusion in Orthopedic Patients

_____ is taking part in a study of postoperative develop confusion in orthopedic patients. Should he/she develop confusion as evidenced by the criteria below, please call _____. Telephone #_____, Beeper # _____ who will come as soon as possible to do an assessment and suggest appropriate management. Please refrain from giving anti-psychotic or sedating medications or using restraints before _____ is notified.

_____ will also be calling on a twice daily basis to review your assessment of evidence for confusion in the patient, using the same criteria listed below. Again, should any evidence for confusion exist, he will come to assess the patient as soon as possible If the patient appears confused by the following criteria, between the time of calls (6:30 am and 10:00 pm) please call him.

Telephone Confusion Assessment Screen for Nurses

Has there been an acute change in the patient's mental status? Does the abnormal behaviour come and go, or increase/decrease in severity?
Is the patient having difficulty focusing attention? Is he/she easily distractible, or having difficulty keeping track of what you or others say?
Is the patient's thinking or conversation disorganized or incoherent?
How would you rate the patient's level of consciousness? a. Alert (normal) b. Vigilant (hyperactive or agitated) c. Lethargic (drowsy but easily aroused) d. Stuporous (difficult to arouse) e. Comatous (unarousable)
Has the patient's sleep-wake cycle been abnormal? Has the patient's activity appeared unusually sluggish, or restless? Is the patient oriented to time, place or person?

APPENDIX 2

CONSENT FORM

TITLE OF RESEARCH PROJECT: *"Prediction of Post-Operative confusion in elderly patients undergoing elective orthopedic procedures"*

INVESTIGATORS: *B.W. Fisher, MD, and A.J. B. McEwen, MD*
Tele. # 492-3605

INFORMATION:

Episodes of confusion occur in patients during the recovery period after orthopedic surgery rather commonly, and when severe enough, can lead to increased hospital stay and suboptimal benefits from the surgery. At this time there are no reliable screening methods to predict who will develop post-operative confusion.

The purpose of this study is to assess patients presenting to the orthopedic pre-admissions clinic prior to surgery, and through history taking and physical examination as well as:

(1) *two brief questionnaires (cognitive tests) which assess your thinking, memory and other mental skills, as well as your ability to perform normal daily activities, and,*

(2) *a form of brain scanning, called HMPAO SPECT scanning, which looks at blood flow to the brain,*

the above named investigators hope to derive useful screening methods for the prediction of post-operative confusion. This would allow for better direction of resources and care to those at highest risk, an action which in turn could reduce the occurrence of post-operative confusion, or at least lessen its severity should it develop.

Your participation in this study would mean spending an extra 20 to 30 minutes of your time on your pre-operative assessment day, in order to administer the tests. This would not interfere with your "routine" assessment but would merely make it more thorough. In addition the HMPAO Spect brain scan would be done. It takes about 1 to 1 ½ hours total time. A small amount (less than 1 tsp) of mildly radioactive substance (the HMPAO) would be injected into an arm vein after which the scan would be taken. Aside from the possible slight discomfort from the injection there are no known side effects from this routinely used scan (approved by National Health Food and Drug Directorate). The amount of radiation involved is very little, being about that amount to which we are all exposed in one year from the natural environment. To avoid an extra puncture, your routine pre-operative blood work would be withdrawn from the same site, prior to the HMPAO injection.

After your surgery, the cognitive tests would be repeated on day one, and another SPECT scan on day three to five after surgery. During your stay you would be closely watched for the development of confusion. Should it occur the protocol would ensure your rapid assessment and treatment.

Because you have been asked to participate as a normal subject it is likely that no current or future benefit to you may arise. However should any significant abnormalities be found on the study they will be discussed with you either directly or through your attending physician.

APPENDIX 2

CONSENT

I acknowledge that, the research procedures described on the Information Sheet (attached) and of which I have a copy have been explained to me, and that any questions that I have asked have been answered to my satisfaction. In addition, I know that I may contact the person named below, if I have further questions either now or in the future. I have been informed of the alternatives to participation in this study. I understand the possible benefits of joining the research study, as well as the possible risks and discomforts. I have been assured that personal records relating to this study will be kept confidential. I understand that I am free to withdraw from the study at any time and that this will not affect my continuing medical care. I further understand that if the study is not undertaken, or if it is discontinued at any time, the quality of my medical care will not be affected. I understand that if any knowledge gained from the study becomes available and that could influence my decision to continue in this study, I will be promptly informed.

_____
(Name)

The person who may be contacted about the research is:

_____

*Telephone No.*_____

_____
(Signature of subject, or person authorized to sign on behalf of the subject, e g , parent)

_____
(Name)

_____
(Signature of Witness)

_____
(Date)

_____
(Signature of investigator or designee)

APPENDIX 3

NAME _____ AGE ____ SEX ___

PROCEDURE _____ DATE OF OR _____

DATE OF ASSESSMENT _____

HGT _____ WGT _____ LOSS? _____ DIET _____

MEDICATIONS: EA _____

MEDICAL HISTORY:

1. Cardiovascular (i) CHF orthopnea _____ edema _____
   PND _____ NYHA class^n _____
   (ii) CAD angina _____ MI _____
   (iii) Arrythmia/pacer/syncope/faints _____
   (iv) PVD/claudication _____
   (v) Hypertension _____
   (vi) Valvular heart disease/SE/proph _____
2. Stroke/residual deficits _____
3. Lipid abnormalities _____
4. Pulmonary (i) chronic/productive cough _____
   (ii) chronic bronchitis/emphysema _____
   (iii) [illegible] _____ (iv) amber _____ (v) Tb hx _____
5. GI (i) jaundice/hepatitis/cirrhosis _____
   (ii) peptic ulcer disease _____
   (iii) other _____ (iv) etoh _____
6. Hematology (i) anemia _____ (ii) DVT/PE _____
   (ii) bleeding _____ (iv) transfusion/rxn _____
7. Endocrine (i) diabetes _____
   (ii) thyroid _____ (iii) Addison's/steroid use _____
8. Renal (i) UTI _____ (ii) prostate _____ (iii) other _____
9. Rheumatology _____

SURGICAL HISTORY:

COGNITIVE/FUNCTIONAL HISTORY:

1. (i) frequent falls _____ (iv) Nocturnal confusion _____
   (ii) Getting lost _____ (v) Prior episode PBC _____
   (iii) Incontinence: fecal _____ (vi) Prior episode pa complic _____
   urine _____ (vii) Prior smooth complic _____
2. (i) "Do you often feel sad or depressed?" Yes ____ No ____
   (ii) "Do you often have unexplained mood swings?" Yes ____ No ____
   (iii) "Who would be able to help you in case of illness or emergency?" _____
   (a) proximity _____ (c) capability of care-giver _____
   (b) frequency of contact _____

APPENDIX 4

PHYSICAL EXAMINATION

DATE OF ASSESSMENT: _____

BP supine _____ BP standing _____ HR/rhythm _____ RR _____

Visual acuity: uncorrected corrected

OD _____ _____

OS _____ _____

Hearing whisper test: (L) ear "what is your name" (+) ____ (-) ____

(R) ear "thirty-two" (+) ____ (-) ____

Thyroid: _____ Fundi (R) _____ (L) _____

Chest:

Cardiac: JVP _____ edema _____ pulses _____ bruits _____

S1 _____ S2 _____ S3 _____ S4 _____ M _____

other _____

MSK: Able to touch back of head with clasped hands? Yes ____ No ____

Able to pick up pencil from exam table with dominant hand? Yes ____ No ____

Transfer from chair to table: unable _____ slowly, unassisted _____

able, assisted _____ quickly, unassisted _____

Neurological: moves all 4 limbs _____

reflexes _____ Babinski _____

tone: arm _____ leg _____

muscle wasting? _____

cerebellar: finger-nose _____ heel-shin _____

Romberg: _____

primitive reflexes: grasp _____ root _____ suck _____ palmomental _____

emotional lability _____

LAB: Hb _____ Na _____ Cl _____ gluc _____ PT/PTT _____

WBC _____ K+ _____ HCO_3 _____ BUN _____ other _____

platelets _____

LFT _____ CXR _____

ECG _____

ECT _____

APPENDIX 5

ADLS	*WITHOUT HELP*	*WITH SOME HELP*	*COMPLETELY UNABLE*
1. Can you feed yourself ?			
2. Can you dress and undress yourself ?			
3. Can you walk ?			
4. Can you get in and out of bed ?			
5. Can you take a bath or shower ?			
6. Can you groom yourself ? *(men: shave women: hair/makeup)*			

IADLS	*WITHOUT HELP*	*WITH SOME HELP*	*COMPLETELY UNABLE*
1. Can you use the telephone ?			
2. Can you get to places outside of walking distance ?			
3. Can you shop for food or clothes ?			
4. Can you prepare your own meals ?			
5. Can you handle your own money and finances ?			
6. Can you do your own housework ?			

APPENDIX 6

NAME _____ Operation

AGE _____ DATE _____

SEX _____ O.R. DATE _____
(if known)

I.	**Orientation (maximum score 10)** Ask "What is today's date?" Then ask specifically for parts omitted, eg. "Can you also tell me what season it is?" Ask "Can you tell me the name of this hospital?" "What floor are we on?" "What town (or city) are we in?" "What province are we in?" "What country are we in?"	Date eg. January 21) Year Month Day(eg Monday) Season Hospital Floor Town/city Province Country	1 2. 3 4. 5. 6. 7. 8. 9. 10.
II.	**Registration (maximum score, three)** Ask the subject if you may test his or her memory. Then say "ball," "flag," "tree" clearly and slowly, about one second for each. After you have said all three words, ask subject to repeat them. This first repetition determines the score (zero to three) but keep saying them (up to six trials) until the subject can repeat all three words. If he or she does not eventually learn all three, recall cannot be meaningfully tested.	"Ball" "Flag" "Tree" Number of trials:	11. 12. 13.
III.	**Attention and calculation (maximum score five)** Ask the subject to begin at 100 and count backward by seven. Stop after five subtractions (93, 86, 79, 72, 65). Score one point for each correct number. **OR** If the subject cannot or will not perform this task, ask him or her to spell the word "world" backward (d, l, r, o, w). The score is one point for each correctly placed letter, eg, dlrow = 5, dlorw = 3. Record how the subject spelled "world" backward: D L R O W	"93" "86" "79" "72" "65" Number of correctly Placed letters	14. 15. 16. 17. 18. 19
IV.	**Recall (maximum score three)** Ask the subject to recall the three words you previously asked him or her to remember (learned in registration).	"Ball" "Flag" "Tree"	20. 21. 22.
V.	**Language (maximum score 9)** Naming: show the subject a watch and ask "What is this?" Repeat for pencil. Score one point for each item named correctly. Repetition: ask the subject to repeat, "No ifs, ands, or buts." Score one point for correct repetition. Three-stage command: give subject a piece of blank paper and say, "Take the paper in your right hand, fold it in half, and put it on the floor." Score one point for each action performed correctly. Reading: on a blank piece of paper, print the sentence, "close your eyes," in letters large enough for the subject to see clearly. Ask subject to read it and do what it says. Score correct only if he or she actually closes his or her eyes. Writing: give the subject a blank piece of paper and ask him or her to write a sentence. It is to be written spontaneously. It must contain a subject and verb, and make sense. Correct grammar and punctuation are not necessary. Copying: on a clean piece of paper, draw intersection pentagons, each side about one inch, and ask subject to copy it exactly as it is. All 10 angles must be present and two must intersect to score one point. Tremor and rotation are ignored. Eg. 	Watch Pencil Repetition Takes in right hand Folds in half Puts on floor Closes eyes Writes sentence Draws pentagons	23 24 25 26. 27. 28. 29. 30 31
	Score: add number of correct responses. In section III include items 14-18 or item 19, not both (Maximum total score 30).	Total score	

Rate subjects level of consciousness: _____ (a) coma, (b) stupor, (c) drowsy, (d) alert

Adapted from Folstein.

APPENDIX 7

History and Physical in Confused Patient

HISTORY:
Fever ( )
SOB ( ) Orthopnea ( ) Cough ( ) Chest pain ( ) _____
Urinary retention ( ) incontinence ( ) foul smell ( ) _____
Constipation ( ) stool incontinence ( ) _____
Fluid intake/output ( ) _____
Weight gain ( ) _____
Recent falls ( ) _____
Drugs:

PHYSICAL: BP _____ HR _____ RR _____ T _____
T baseline _____

Cyanosis ( ) respiratory distress ( ) dehydration ( ) ANS instability ( )
Pupils _____ Sensorium _____ Vision (if glasses: present?) _____
Hearing (if aid: present?) _____
Neck Stiffness ( )
CHF ( ) ↑JVP ( ) Inspiratory crackles ( ) Edema ( ) S4/S3 ( )
Stroke ( ) _____
Focal Deficits ( ) _____
Asterexis ( ) _____
Upper and lower limb motility abnormal? ( ) _____
Evidence of trauma? ( ) _____
LAB:

Na _____	Cr _____	Glucose _____	EKG _____
K+ _____	HCO_3 _____	BUN _____	CXR _____
	ABG _____	CR _____	
		Ca++ _____	Other _____

Confusion Assessment Method (CAM) Diagnostic Algorithm (Inouye et al, 1990)

Feature 1. Acute Onset and Fluctuating Course
Is there evidence of an acute change in mental status from the patient's baseline? Did the (abnormal) behaviour fluctuate during the day, that is, tend to come and go, or increase and decrease in severity?

Feature 2. Inattention
Did the patient have difficulty focusing attention, for example, being easily distractible, or have difficulty keeping track of what was being said?

Feature 3. Disorganized Thinking
Was the patient's thinking disorganized or incoherent, such as rambling or irrelevant conversation, unclear or illogical flow of ideas, or unpredictable switching from subject to subject?

Feature 4. Altered Level of Consciousness
Overall, how would you rate this patient's level of consciousness? (alert [normal], vigilant [hyperalert], lethargic [drowsy, easily aroused], stupor [difficult to arouse], or coma [unarousable]).

---

*The diagnosis of delirium by CAM requires the presence of features 1 and 2 and either 3 or 4.

APPENDIX 8

Clock Drawing Administration and Scoring System

Patients are given a sheet of paper with a predrawn 8 cm circle, and a large pen or felt-tipped marker. They are asked to put the numbers on the clock and place the hands to make it read 10 minutes past 3 o'clock. These same instructions are repeated as often as needed but no other directions or new instruction are given. No attempts are made to cover up any time pieces in the rooms.

A scoring system, modified from those of Sunderland et al. and Wolf-Klein et al., was used. A score of 6 or less constitutes an abnormally drawn clock.

Score

10. Hands and numbers are all present and in the correct positions. Corrections without prompting are accepted as normal.

9. There are slight errors in placement of hands or 1 missing number without spacing errors.

8. There are moderate errors in placement of hands or confusion as to small and large hands or spacing errors alone.

7. The placement of hands is significantly off course or spacing is inappropriate.

6. Clock hands are used inappropriately or there is use of digital display, circling of numbers, or perseveration in the writing of the numbers.

5. Numbers are crowded to one end of the clock, reversed in order, or absent.

4. There is further distortion of the number sequence, counterclockwise order, many missing numbers, or numbers placed outside the clock face border.

3. The numbers and clock face are no longer connected in the drawing.

2. Only vague representation of a clock or irrelevant spatial representation exist.

1. The result is uninterpretable or no attempt is made.

APPENDIX 9

PATIENT CONTROLLED ANALGESIA

Intravenous analgesia may be delivered to the patient, who, by pressing a button, activates a bolus through an intravenous pump. After a dose is delivered, the pump will not respond to further requests for about 15 minutes to insure the analgesia has had time to work before more is requested. Individual bolus amounts are pre-prescribed by the physician. Generally, the pump is discontinued after 2 or 3 days, and oral analgesics substituted.

Patients using this method of postoperative analgesic have been shown to:

1. Avoid delay in receiving pain reliever.
2. Become less drowsy for given degree of pain relief.
3. Use less pain medication than those patients having conventional nurse administered injections.