Design of Novel Assessment Techniques for Opioid Dependent Patients

Sushil G. Patil, Timothy J. Gale, Clive R. Stack

Abstract—Assessment of opioid dependent patients in a replacement program has traditionally relied on conventional methods such as urine testing or face to face examination with a physician. We are introducing new assessment techniques based on pupillometry, reaction time and slurring of speech. The pupillometry test uses a webcam, controlled lighting and customized software to measure pupil parameters. The reaction time test uses a push-button to detect time to respond to a visual stimulus. The slurred speech test involves detection of slurring of a set of individual test words. These three tests will be combined to provide the physician with an objective “sedation index” for patients. These techniques will be used with remote dispensing technology currently under development.

I. INTRODUCTION

Drug dependence is a complex condition involving social, psychological and biological components. Millions of people around the world are opioid dependent and the number is increasing. In USA alone near one million people are believed to be opioid dependent and around 179,000 are currently enrolled in methadone treatment [1].

Symptoms: Symptoms of intoxication with CNS depressants include slurred speech, delay in reaction to stimuli, drowsiness, poor balance, retarded movement, unsteady gait, pin point pupils etc. Other symptoms indicating more serious effects are respiratory depression and coma [2].

Methadone Treatment: Methadone, (opioid substitute) replacement programs have been established as an effective harm minimization treatment system for opioid dependent patients [3,4,5]. Use of methadone produces symptoms similar to those observed for other opioids. Assessment of patients immediately prior to methadone consumption is usually done to detect patients already intoxicated (by methadone, alcohol or other drugs), as dosing when intoxicated may be fatal. Currently, however, patients consuming “take-away” doses (typically a three-day supply) are not assessed prior to consumption. We are developing methods for remote assessment of these patients, to improve the safety of take-away dosing.

Current assessment techniques includes subjective assessment by medical professionals and urine testing [6,11], although recently pupillometry has been found effective [7]. Pupillometry provides an objective measure of the intensity of opiate use in subjects [8]. Pupillometry has the advantage over urine testing of being uncomplicated, cheap and quick while still being accurate.

The relationship between pupil size and subjective symptoms of opiate withdrawal during gradual opiate agonist detoxification has been studied [9, 10]. The dilator muscle of the pupil is innervated by noradrenergic nerve fibers that use norepinephrine as a transmitter, whereas the constrictor muscle uses acetylcholine (Ach) as a neurotransmitter. During opiate withdrawal, increase in central noradrenergic activity is thought to be responsible for increase in pupil size. Increased dosing results in a smaller pupil diameter, presumably related to opiates diminishing central noradrenergic activity [11].

Pupillometry

Pupillometry is a procedure that measures two important geometrical characteristics of the pupil viz pupil size and pupil location with respect to the anatomical structure of the eye. Commercial pupillometers range from specially designed rulers or gauges to highly sophisticated infrared video-based systems. Several recent studies of accuracy and reliability of popular pupillometers have been conducted [12, 13]. Using gauges pupil diameter was measured to an accuracy of ±1mm [14]. Infrared tube-based pupillometers are more accurate than the gauges. They often provide a digital read out of pupil size to ±0.5mm. Most accurate systems are based on objective infrared video systems with accuracy of about ±0.1mm. Pupil parameters can also be estimated with a videokeratoscope, an instrument primarily used for measuring corneal elevation [7]. However, the accuracy of this methodology has been questioned for eyes with dark irises [8].

Although pupillometry is commonly applied in the cases above, there are some disadvantages. Current pupillometers do not measure the location of the pupil center in reference to the corneal limbus. As a consequence, measurement of the magnitude and direction of changes in the pupil center with light level changes cannot be directly performed. However, in other clinical applications the pupil parameters are often manually estimated from photographs and video images. Also, most commercial pupillometers assume that the outline of the pupil is circular, providing only an estimate of the pupil diameter. On the contrary, the pupil is noncircular with

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irregularities that are often visible with the unaided eye. While no studies have reported using slurring in speech or reaction to a stimulus as an assessment tool prior to dosing, cocaine's effects on speech sound identification and reaction times in baboons have been studied [15]. Baboons were trained to release a lever on a particular vowel sound to test speech identification. Reaction time was taken as the time taken by the baboon to release the lever after hearing the sound of the vowel. Dose dependent decrease in vowel discrimination was demonstrated.

“Detection of slurred speech” is one of the primary indicators used in conventional assessment, but there are currently no methods available that give objective measures of this characteristic. However, Neural Network techniques are commonly used for speech recognition and may prove effective for the detection of slurred speech.

Our aim in this study is to develop an assessment system for opioid dependent patients which includes three different assessments: pupillometry, a reaction time test and a slurred speech test. This system is intended to assist the physician by providing a more global objective measure of “level of sedation”.

### TABLE 1. Apparatus used in the Patient Assessment System

<table>
<thead>
<tr>
<th>Name</th>
<th>Brand</th>
<th>Specifications</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital Multimedia Headset</td>
<td>Plantronics</td>
<td>Speaker Frequency response: 20Hz – 20 Khz</td>
<td>Slurred speech</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Microphone Frequency Response: 100Hz – 10kHz</td>
<td></td>
</tr>
<tr>
<td>USB Webcam</td>
<td>Genius Trek 310</td>
<td>Sensor Type: VGA (640X480) CMOS Video Resolution: 640X480</td>
<td>Pupil diameter</td>
</tr>
<tr>
<td>Goggles</td>
<td>Protector</td>
<td></td>
<td>Pupil diameter</td>
</tr>
</tbody>
</table>

Figure 1. Patient monitoring system user
II. METHOD

The software for the assessment system was developed in Matlab R2006b (Mathworks, USA). The apparatus used with the software in shown in Table 1. The software user interface is shown in Fig 1. The software consists of the three tests, patient details, and comments from the physician. Patients are identified with a unique identity code such as SD0001. A new patient is given a new identity code by the physician before conducting the first test. The details of the patient can be entered in a new window that assigns the unique identity code. The details include Name, Age, Sex, Patient Id. Patient photo, and other unique details specific to the patient as shown in Fig 2.

The software allows selection of the patient Id from the drop down menu or entering of a new id. The test number is automatically incremented if a previous test has been carried out, or the number 1 by default. The software acquires the date and time for the test from the computer. The physician selects a standard set of data from the user interface specific for the patient such as the type of medication (*1 on Fig 1) and whether the patient is sedated or not sedated (*2 on Fig 1).

Reaction Time Test

In this test a large button (shown in Fig 1) changes color from black to white and vice versa at random time intervals. The patients are required to click the PC mouse over the button when it turns black. The time delay from the button turning black to the click of the mouse by the patient is saved. This test is repeated 5 times.

Slurred Speech

The patient will be asked to repeat 5 sets of words. These sets of words will be decided based on the propensity for slurring as detected by the length and number of peaks in the digitized waveform. These words will be played and the patient can hear it through the digital multimedia set described in the Table 1. The patient repeats the words as per the instructions and the microphone acts as receiver for the patient speech with 16kHz/16bit sampling. The word is displayed as a function of time and amplitude and saved as *.wav file. The stop button stops the recording after a single word is spoken.

Pupillometry

A USB webcam is fixed in one eyepiece of a goggle (Table 1). The focus of the webcam will be kept fixed for all the measurements. Four LED’s will be used to create illumination inside the goggle, as measured by a light sensor. The webcam is used for online video streaming. In Fig 1 “Open/Browse” starts the video and “capture” saves a single frame. A counter besides “capture” indicates how many (up to five) frames have been captured from the video.

Pupil and iris radius are calculated using Ishander’s method [16], where images are converted from color to grey level and estimates of the center of the iris and pupil obtained using a quadruple symmetry indicator. This is followed by various image processing techniques involving limbus...

III. CONCLUSION

This is novel work that will, for the first time, enable objective assessment of opioid dependant patients prior to dosing, and will facilitate the development of remote assessment methods for use with opioid dependent patients.

REFERENCES


