The use of painful stimulus in relation to Glasgow Coma Scale observations

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For over 30 years the Glasgow Coma Scale (GCS) has been used to assess a patient's level of consciousness following a head injury or any other cerebral insult likely to cause neurological deterioration (Fisher and Mathieson, 2001). It presents a visual trend of observations (Palmer and Knight, 2006) and establishes an essential baseline from which the practitioner can gauge the degree of improvement or deterioration prompting further interventions as clinically indicated.

Despite the apparent simplicity of this tool, some practitioners, particularly those who infrequently perform GCS observations, encounter difficulties completing the assessment and often have problems identifying the more subtle signs of deterioration. The National Neuroscience Benchmarking Group (NNBG), working with the British Association of Neuroscience Nurses (BANN), have written standards and guidance for the performance of neurological observations based on the knowledge, skills and expertise of skilled nurses working in neuroscience units throughout the country.

More recently, there have been some excellent publications that have tried to clarify some of the subjective and confusing aspects associated with the performance of the observations, such as applying painful stimuli to sedated patients, the assessment of patients who are intoxicated with alcohol or drugs, and the application of different types of stimuli (Livingston et al, 2000; Brunker, 2006; Palmer and Knight, 2006; Baker, 2008).

An article written by Judith Lower, 'Rapid neuro assessment', published in the *American Journal of Nursing* in 1992, contained detailed and comprehensive instruction on how to carry out a neurological assessment presenting an escalation ladder of when and how to stimulate the patient using the acronym, 'voice, shout, shake, pain'. This is commonly now used in critical assessment (Advanced Trauma Life Support and American College of Surgeons, 1993). Lower deliberated on the choice of central painful stimuli once verbal response has failed and advocated the use of the trapezius squeeze, followed by pressure applied over the supraorbital ridge. Lower went on to state:

> **the sternal rub is a third effective means of central stimulation. With your knuckles, act as if you are grinding a pill in the middle of the patient's sternum. Done correctly, this mortar-and-pestle motion should leave the imprint of your knuckles in the patient's soft tissue, and the imprint of your finger nails in your own palm.**

The aim of applying painful stimuli is to assess the level of consciousness or the depth of coma in a patient who is in an altered state, but not to cause long-term pain or damage that could be interpreted as a sign of battery or abuse (Fairley and Cosgrove, 1999). While Lower qualified her statement by acknowledging that repeated use of sternal rubbing would result in bruising, in practice, damage to the soft tissue over the sternum is inevitable.

For several years now this practice has been strongly discouraged but is still frequently observed in the acutely ill 'neuro' patient (*Figure 1*). Anecdotally, practitioners have reported the use of alternative painful stimuli such as twisting ear lobes, calf or upper arm pinching, temporomandibular joint compression or even stimulating the plantar reflex (Woodward, 2007).

A recent project questioning and observing nurses performing GCS observations in a variety of settings showed that the sternal rub is frequently used by many health professionals in clinical practice (Waterhouse, 2008).

ABSTRACT

The Glasgow Coma Scale is a well established and invaluable tool that enables practitioners to make systematic and rapid evaluations of several key indicators of neurological status. The National Neuroscience Benchmarking Group has written standards and guidelines for the performance of neurological observations based on the best evidence, knowledge and skills of nurses from around the UK, which is available to members of the benchmarking group and the British Association of Neuroscience Nurses. However, discussion continues about the most effective and appropriate method of applying painful stimulus and the requirement to use a central or a peripheral pain stimulus. An understanding of the pathophysiological basis for the procedure may help guide and direct future management options.

Key words

■ Glasgow Coma Scale ■ Neurological assessment ■ Painful stimulus ■ Sensory and motor nerve pathways ■ Benchmarking standards

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Figure 1. Glasgow Coma Scale (Jennett and Teasdale, 1977)

Eye Opening (C=closed)	Spontaneously	4			
	To speech	3			
	To pain	2			
	None	1			
Best Verbal Response (T=tracheostomy/ endotracheal tube)	Orientated	5			
	Confused	4			
	Inappropriate words	3			
	Incomprehensible sounds	2			
	None	1			
Best Motor Response	Obeys commands	6			
	Localizes to pain	5			
	Normal flexion/withdrawal	4			
	Abnormal flexion	3			
	Extension	2			
	None	1			

Similarly, speaking to newly-qualified doctors attending the Advanced Trauma and Life Support (ATLS) course, it appeared to be an almost automatic response within the simulated clinical scenarios. Not surprisingly, it is frequently the method of choice for many medical staff in the clinical area when a central painful stimulus is required.

To use the GCS chart efficiently and effectively, it is essential that all practitioners apply the same stimulus in the same manner and assess each patient in the same way. The recording of an accurate baseline is the most important aspect of the tool. Failure to stimulate the patient sufficiently to obtain an accurate picture of his/her neurological responses may affect the practitioner's ability to identify the earliest subtle signs of deterioration and react to these changes promptly (Frawley, 1990; Shah, 1999).

Benchmarking is a dynamic process which means that every 2 years current practice guidelines are reviewed. It involves searching out the best evidence to support the relevant standards and when there is little or no information or research, the practitioners give their opinion, based on their experiences and what they believe to be the best practice. While consensus opinion has agreed the method of applying painful stimulus, there still is no unanimous agreement as to which is the optimal method of assessment. Principal concerns relate to the difficulties assessing patients with communication difficulties, extensive facial fractures or spinal injuries, as well as the training and competence issues related to the correct application of the stimulus. It is perhaps prudent at this time to explore some of the 'science' behind the actions of practitioners and identify the physiological components underpinning the peripheral versus central painful stimulus debate. It is important to ask:

- What do health practitioners do to assess consciousness?
- Why do practitioners assess consciousness in this way?
- How is consciousness assessed?
- Are there alternative ways?

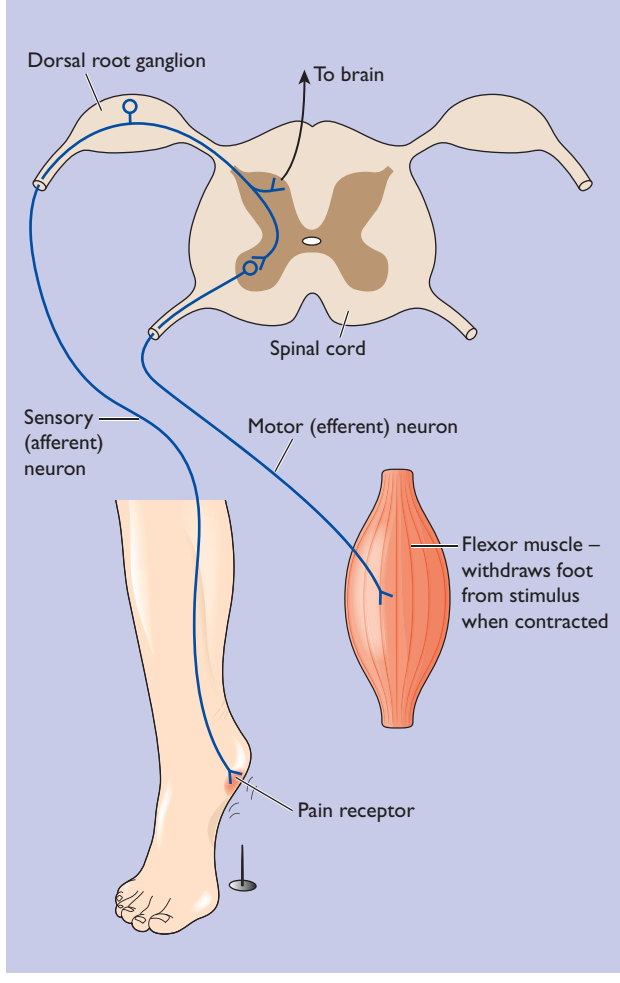
Table 1. Physiological components of the Glasgow Coma Scale

	Behaviour	Response	Associated anatomy
E	Eye opening	Arousal and wakefulness	Brain stem function (reticular activating system)
V	Verbal response	Orientation and communication	General interpretive speech and language area in the temporal lobe
M	Motor response	Initiate movement to commands	Primary motor and sensory cortex

What do health practitioners do to assess consciousness?

The GCS evaluates three key categories of behaviour: eye-opening, verbal response and motor response. Each section reflects the physiological activity in a specific area of the brain (*Table 1*), and is allocated a numerical value to the level of response, represented in a scale of increasing neurological deterioration (*Figure 2*). The maximum score that a patient can achieve is 15, signifying an awake, alert and fully responsive patient; the lowest score is 3, indicating total unresponsiveness (Teasdale and Jennett, 1974).

Figure 2. Simple spinal reflex action



There are only two sections on the chart that potentially require the application of a painful stimulus, namely eye-opening and best motor response (Teasdale and Murray, 2000). By the time a practitioner needs to apply a painful stimulus, he/she is already beginning to have serious concerns about the patient's neurological status and the application of painful stimulus signifies the last attempt to trigger the arousal mechanisms in the brain to ascertain the level of cortical functioning (Palmer and Knight, 2006).

Errors are common when practitioners fail to stimulate the patient effectively to determine his/her best response to pain and inexperienced practitioners are often reticent to apply an adequate amount of pressure to elicit a sufficient response (Rowling and Fielding, 1991; Waterhouse, 2008). As Fisher and Mathieson (2001) state:

> **consistency in the application of the GCS is found to be essential to ensure that the tool is a valid indicator of the patient's clinical condition.**

Why do practitioners assess consciousness in this way?

There are two basic types of stimulation: a peripheral or a central painful stimulus. The choice of stimulus depends on the reaction that the practitioner needs to generate.

Peripheral painful stimulus (eye-opening response)

The ability of a person to open his/her eyes is a good indication that the patient is not only awake but aware of his/her surroundings. This response relies on a functional arousal mechanism, a collection of complex neurones, known as the reticular activating system (RAS) that forms part of the reticular formation in the brainstem, responsible for triggering and maintaining consciousness. Pathways extend through to the thalamic nuclei modifying and relaying sensory information from the environment to the cerebral cortex for interpretation (Addison and Crawford, 1999; Martini and Nath, 2008). Disruption of these pathways will result in a reduced level of arousal and awareness and the GCS score will be correspondingly reduced (Palmer and Knight, 2006).

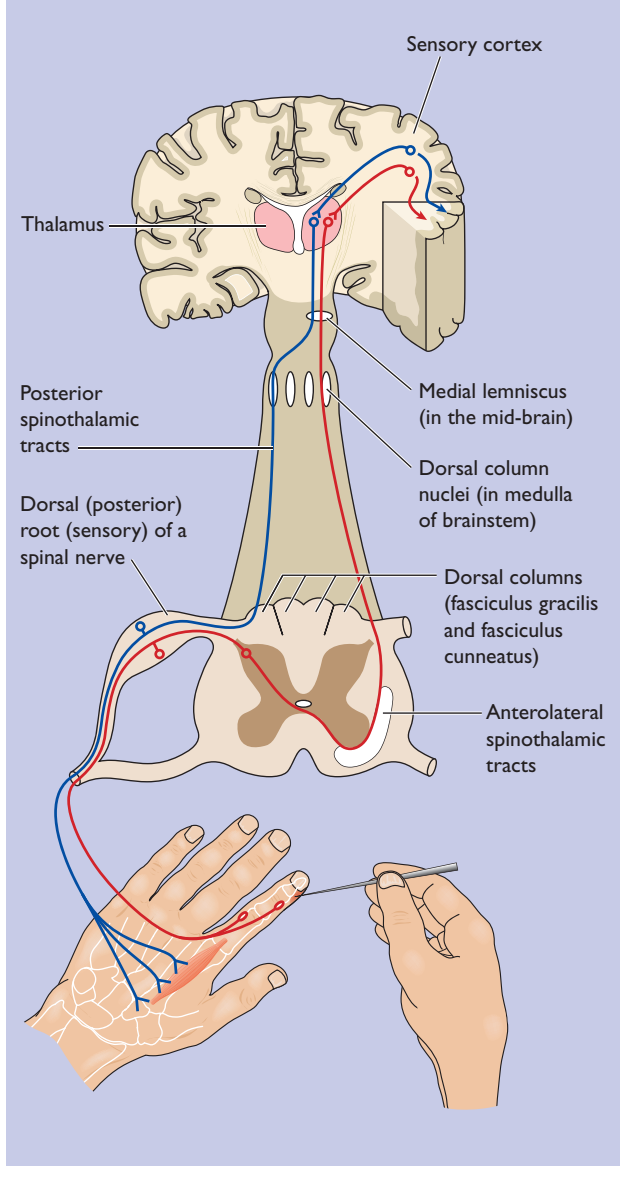
Initially, a peripheral pain will excite the superficial nociceptors in the skin transmitting impulses along primary sensory (afferent) nerve tracts to interneurone connections in the dorsal (posterior) horn of the spinal cord. The nerve pathways then followed by the signal depend on the type of sensation. Pain axons immediately decussate and the impulse ascends along the lateral spinothalamic tracts to the ventral posterior lateral nucleus of the thalamus. Sensory neurones continue to ascend via the internal capsule to reach the somato-sensory cortex in the post-central gyrus of the parietal lobe, where the nature and intensity of the sensation is localized and interpreted, thereby triggering the patient to open his/her eyes.

At the same time however, sensory information can be interpreted at a spinal level and the remaining sensory neurones can immediately synapse with motor neurones within the spinal cord, innervating a muscle and causing rapid, involuntary contraction and movement of the limb, thereby activating a reflex or withdrawal action by completion of the reflex arc (Marieb and Hoehn, 2004). Modulation and reciprocal inhibition occurs from nerve impulses descending from the cerebral cortex and brainstem with ascending fibres simultaneously providing conscious awareness of the painful stimulus (*Figure 2*).

How is peripheral painful stimulus used to assess consciousness?

A peripheral painful stimulus is applied to the extremities and is used if the patient fails to open his/her eyes spontaneously (GCS 4/4), or respond to verbal voice commands (GCS 3/4) (*Figure 3*). Often asking the patient if he/she 'wants a cup of tea' can achieve a greater response than simply calling the patient's name or asking him/her to 'open your eyes'. In the first instance, a touch or gentle shake may be sufficient to gain the patient's attention;

Figure 3. Applying a peripheral painful stimulus



however, if a deeper stimulus is required because no response is elicited, the intensity of the stimulus must be gradually increased (Fielding and Rowling, 1990; Price, 2002).

Peripheral stimulation involves applying pressure with a pen to the lateral outer aspect of the second or third interpharangeal joint (applied with graduating intensity for 10–15 seconds). It is sometimes necessary to repeat the process to ensure an accurate baseline has been achieved. The patient should respond by opening his/her eyes to inspect the source of the injury or the perpetrator of the assault (GCS 2/4). In addition the patient may attempt to move the limb away from the pain.

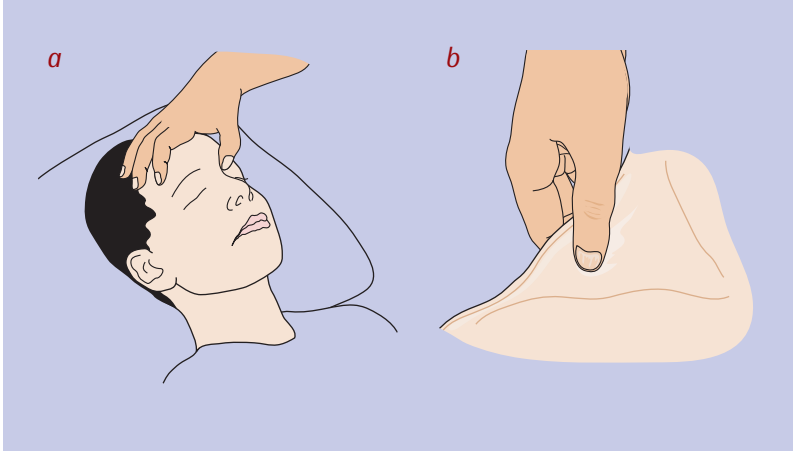
Central painful stimulus (motor response)

A central stimulus applies noxious painful stimuli to the 'core' of the central nervous system, i.e. the cranial nerves, to produce a complete motor response from the body. It is used to assess the integrity of the higher centres of the brain in an area where it is not possible to activate a reflex action response. The trigeminal nerve (V), or the spinal accessory nerve (XI), are probably the easiest nerves to locate. The supraorbital nerve, the ophthalmic portion of the trigeminal nerve, runs through the superior orbital fissure, palpable as a small notch lying just underneath the eyebrow (Bader and Littlejohns, 2004; Guyton and Hall, 2006) (*Figure 4a*). The spinal accessory nerve (XI), originating from neuronal cell bodies in the upper cervical spinal cord (C3, 4 and 5), and the brainstem medulla (nucleus ambiguus), lies under the trapezius and sternocleidomastoid muscles in the neck and back (Martini and Nath, 2008; Thibodeau and Patton, 2003) (*Figure 4b*).

Sensory impulses (pain and pressure), are conducted along the cranial nerves to the pons synapsing on second-order neurones in the ipsilateral trigeminal nucleus and ascending via the lateral or ventral spinothalamic tracts to the ventral posteromedial nucleus in the thalamus. Collateral branches of the trigeminothalamic tract neurones project to the reticular formation to stimulate wakefulness and awareness; the remaining neurones pass into the internal capsule ending in the somatic sensory cortex (Seeley et al, 2006).

A motor response is transmitted from the precentral gyrus in the cerebral cortex, decussating in the medulla and descending down the spinal cord via the lateral corticospinal tracts to their target levels in the anterior horn. Exiting from the ventral nerve root, the impulse will synapse on an interneurone or directly onto an efferent motor neurone innervating the distil muscle and causing the patient to move or remove the limb from the source of the pain.

Figure 4. Applying a central peripheral painful stimulus



How is central painful stimulus used to assess consciousness?

If the patient is unable to obey simple commands, the nurse's hand rests on the head of the patient and the flat of the nurse's thumb is placed on the supraorbital ridge. Pressure is gradually increased for a maximum of 10–20 seconds until the patient:

- Responds by localizing towards the stimulus in an attempt to remove the source of the pain (GCS 5/6)
- Merely flexes or weakly withdraws his/her arm in response (GCS 4/6)
- Abnormally flexes (GCS 3/6) or extends his/her arm away from the stimulus (GCS 2/6).

These responses reflect progressive damage and loss of higher level function in the brain. The procedure is contraindicated if there is evidence of orbital, facial or skull fractures or in the presence of glaucoma (Barker, 2002).

Similarly, if using the trapezius squeeze, graduating degrees of pressure are applied until the patient attempts to localize towards the stimulus, indicating that the neuronal pathways from the RAS to the sensory and motor cerebral cortex are patent to a greater or lesser extent (Price, 2002; Hickey, 2003; Mcleod, 2004).

The trapezius pinch has always been advocated in the presence of orbital or skull fractures. Similarly, supraorbital ridge pressure is always recommended if the patient has a possible spinal injury. But common sense should dictate that if the patient has a spinal injury that is sufficiently high to blunt sensation at the trapezius muscle, it is highly unlikely that there will be any movement in the arms at all, making the pressure point redundant and irrelevant.

The use of the trapezius squeeze has been questioned by some practitioners (Addison and Crawford, 1999) on the grounds that the spinal accessory nerve is known to have a largely motor function (Martini and Nath, 2008), but has also been shown to have a small sensory component (Bremner-Smith et al, 1999) thereby producing a spinal reflex action when it is pinched. However, while contraction of the trapezius muscle will cause elevation/shrugging of the shoulders, its effect on arm flexion is negligible and any true response must be cerebrally mediated.

Are there alternative ways?

The trigeminal nerve (V nerve), is readily accessible behind the maxillary and mandibular joint. Pressure

applied to the nerve in an upwards and inwards direction is an effective noxious stimulant. However, if not applied with caution, particularly in those neuro patients with raised intracranial pressure, compression around this region may compromise venous return through the jugular vein and exacerbate the primary injury.

Discussion

It was clear from a recent audit observing nurses performing GCS observations in a variety of specialist areas that uncertainty, variation and discrepancies exist in the method of applying painful stimulus and in nurses' understanding of the rationale for using peripheral or central painful stimulus. Unfortunately, it is known that failure to ascertain an accurate baseline due to inadequate or inaccurate stimulation can lead to a misleading baseline with potential catastrophic consequences for the patient (Teasdale et al, 1978). As Teasdale and Jennett (1974) stated:

> **Impaired consciousness is an expression of dysfunction in the brain as a whole.**

Therefore an accurate assessment of a patient's level of consciousness is critical, forming the basis for future clinical management decisions. The inability of a patient to open his/her eyes, verbally communicate, obey commands or move his/her limbs, indicates a degree of disruption or damage to the neuronal pathways from the spinal and cranial nerves to the brainstem and the higher centres of the cerebral cortex.

Pain forms an essential part of the body's protective defence mechanism and therefore painful stimulus is a valuable and necessary tool to aid the neurological assessment. A fundamental responsibility for any nurse is to relieve pain wherever possible, and the prospect of consciously increasing a patient's suffering by deliberately inflicting pain, even to elicit a specific response, can be anathema for many untrained or inexperienced nurses. While applying a peripheral stimulus to assess individual limb power and function is rational and makes sense, particularly if there is a suspicion of cerebral perfusion deficit or a developing progressive hemiparesis, the use of a peripheral stimuli to entice an eye-opening response might be less understandable.

Neuroanatomy is complex and difficult to comprehend. However, an understanding of the underlying mechanisms relating to the nerve pathways, specifically the pain and pressure impulses, could provide a rationale for the way practitioners stimulate the patient. It is obvious from looking at the physiology that sternal rubbing is not a central painful stimulus in the sense that it does not directly target the cranial nerves. Conversely, it does not trigger a reflex action either as it still requires higher level cortical interpretation to enable the patient to respond. It is important to ask what applying pressure in this way is intended to achieve. Practitioners need to observe the 'best response' from the arms to ascertain whether the cerebral cortex is able to interpret sensory messages and translate them into a motor response. Ideally, the practitioner would want his/her patient to localize towards the pain. However, it is difficult to differentiate the response, given the actual source of the stimulus. As a consequence it can be extremely ambiguous and is not much use for assessing motor function accurately.

At a neuroscience conference in 2007, Professor Sir Graham Teasdale said that the GCS was never intended to be a straitjacket and people still needed to use their common sense when implementing the tool. The GCS cannot be used in isolation and other parameters such as vital signs, pupil reaction and subtle changes in behaviour can alert a practitioner to an impending neurological deterioration. Nurses that perform GCS observation on a regular basis have few problems differentiating and applying the different modes of stimulation. However, the application of supraorbital pressure requires instruction and a high degree of competence that practitioners working in other specialties may not have; consequently they may inadvertently cause more trauma than is necessary.

The key point to prompt discussion and debate is, given that irrespective of whether a peripheral sensory stimulus is used to test the function of the RAS (simultaneously provoking a spinal reflex), or a central stimulus that confirms the integrity of the neural connections to the higher centres, both pathways are mediated in the sensory cortex before an appropriate motor response can be initiated. The National Neuroscience Benchmarking Group has recommended the use of supraorbital pressure for the motor response and digital compression for eye-opening in its unpublished standard on neurologial observations. However, it could be questioned whether it is reasonable to expect practitioners who may be required to apply the tool (irrespective of their clinical role and training) to be able to differentiate and understand the need to use different forms of painful stimulus for different purposes.

Painful stimulus is always used judiciously when there are serious concerns about a patient's neurological status—would it be presumptuous therefore to suggest using a single central painful stimulus for both eye-opening and the motor response? If practitioners can elicit two assessments for one pain episode then so much the better. It can be difficult to apply sufficient pressure to the trapezius muscle in the larger or obese patient for it to be effective but the trapezius pinch is definitely the 'safer' option for inexperienced staff who are unlikely to apply supraorbital pressure effectively. Recommendations for practice are listed in *Table 2*.

Table 2. Recommendations for practice

A central painful stimulus should be used in the first instance, if the patient opens his/her eyes and moves his/her arms, the need to use peripheral pain stimulus becomes redundant
Peripheral painful stimulus can be used to assess specific limb function, but should never be applied when it is known the limb is paralysed
The amount of painful stimulus should not be excessive to result in damage to the skin or underlying soft tissues
Where local policy dictates continued use of sternal rubbing, using the flat of the hand should be encouraged to reduce the effects of bruising
Direct pressure over the nail bed is contraindicated as it will damage the capillary bed with probable loss of the nail
The use of alternative stimulus sites should be strongly discouraged
A patient with an actual spinal injury requiring Glasgow Coma Scale observations is complex and relies on meticulous observation of the other parameters such as behaviours. He/she is unlikely to 'eye open' in response to peripheral stimulation and similarly there isn't going to be a motor response to a central pain

Conclusions

The GCS is an objective scoring tool that can be used to perform and compare repeated, rapid evaluations of a patient's level of consciousness. An accurate neurological assessment is absolutely paramount for the early diagnosis and management of the deteriorating neuroscience patient and yet there remains a lack of knowledge of how to elicit the best response from the patient and how to interpret the result in nonspecialist clinical areas. It is essential for practitioners to have the knowledge and skills to perform an accurate assessment and identify the early signs of neurological changes. BJNN

KEY POINTS

- Uncertainty, variation and discrepancies exist in the method of applying painful stimulus and in nurses' understanding of the rationale for using peripheral or central painful stimulus
- An accurate assessment of a patient's level of consciousness is critical, forming the basis for future clinical management decisions
- The amount of painful stimulus should not be excessive to result in damage to the skin or underlying soft tissues
- Where local policy dictates use of sternal rubbing, using the flat of the hand should be encouraged to reduce the effects of bruising
- Direct pressure over the nail bed is contraindicated as it will damage the capillary bed with probable loss of the nail

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