Proposed Standard of Practice and Guidelines on Management of Traumatic Brain Injury, Spinal Cord Injury and Peripheral Nerve Injury by Neurotrauma Committee of Nigerian Academy of Neurological Surgeons

1. INTRODUCTION

This national guideline on traumatic brain injury, spinal cord injury and peripheral nerve injury is aimed at providing guidance and framework for management of trauma patients with traumatic brain injury with or without spinal cord injuries.

It is aimed at promoting effective early management of patients by ensuring immediate clinical assessment so that patients receive the right care for the severity of their injuries by effective clinical assessment, adequate and essential imaging and direct specialist referral.

It is also to serve as a benchmark for management of traumatic brain injury, spinal cord injuries and peripheral nerve injuries by designated trauma centers across the country.

2. PRE-HOSPITAL CARE AND DETERMINATION OF REFERRAL TO HOSPITAL

2.1 Member of Public

The trained neurosurgeon may not be the first to arrive at the scene of trauma. On account of this, the need for care of cervical spine in the pre-hospital setting including the site of the injury must be taken into consideration from this stage. Encourage person(s) who have concerns following head injury to themselves or others to seek immediate medical advice regardless of the extent or severity of injury. They must not move or lift the patient in any way before protecting the cervical spine. Immediate medical attention should be sought in the event of any of the following:

1. Any loss of consciousness (fainting) as a result of the injury, even if the person is recovered/recovering.
2. Amnesia for events before or after the injury/ forgetfulness/ difficulty with memory
3. Persistent headaches following the injury
4. Episodes of vomiting after the injury
5. Altered behavior/Irritability in cases of children

2.2 General Practitioners/Primary Health Care Centers

Medical Officers at PHC and General Practitioners are advised to refer patients who have sustained head injury to Hospital Accident and Emergency Units, if any of the under listed are present.

Initial immediate care should be administered to the patient, with emphasis on treating the greatest threat to life first using standard principle and practice of Advanced Trauma Life Support (ATLS), Advanced Pediatric Life Support (APLS), Pre-hospital Trauma Life Support (PHTLS)courses.

1. Glasgow coma scale (GCS) score of less than 15 on initial assessment
2. Presence of focal neurologic deficit since injury
3. Suspicion of Skull fracture (either open/closed)
4. Amnesia of events preceding or after the injury
5. Persistent headaches since injury
6. Any seizures since injury
7. Current drug or alcohol intoxication or anti coagulation therapy
8. Any previous brain surgery

Cervical motion restriction is advised for patients with head injury and the following risk factors:

1. GCS less than 15
2. Neck pain or tenderness on clinical examination
3. Focal neurologic deficit
4. Paresthesia in the extremities
5. Clinical suspicion of Cervical spine injury

Cervical motion restriction is to be maintained until appropriate image modalities shows it is safe to remove immobilization.

Pain Management—effective pain management is advised, to prevent further increase in intracranial pressure.

Splintage of limb fractures and catheterization of full bladder where needed recommended prior to transfer to Hospital Emergency Department.

3. ASSESSMENT IN HOSPITAL ACCIDENT AND EMERGENCY, EMERGENCY UNITS OR TRAUMA CENTER

1.Patients presenting to Accident and Emergency unit with impaired consciousness (GCS< 15) should be assessed immediately by trained member of staff.

2. The initial assessment by a trained member of staff should be done within maximum 15 minutes of arrival at hospital, and establish if patient is high or low risk for clinically important traumatic brain injury.

3. Patients considered to be low risk for significant traumatic brain injury on initial assessment, should be reassessed within 1 hour by emergency room doctor, to establish need for requesting CT imaging of head/ discussion with the Neurosurgery unit. When in doubt about need for imaging, discuss with the Neurosurgeon.

4. Involve the Neurosurgeon if confusion persist for more than 4hours. If any of the following is noted:

a. deterioration in GCS after initial assessment

b. new onset focal neurologic signs

c. seizure/ seizure without full recovery

d. suspected CSF leak from ears/nose/eyes.

5. Patients considered high risk for significant traumatic brain injury, should have full clinical examination, to establish extent of injuries and need for imagining of the brain, spine and other parts of the body.

6. Priority should be given to stabilization of airway, breathing and circulation (according to ATLS protocol) before attending to other injuries or seeking imaging in patients.

7. Patients who do not satisfy the NEXUS (National Emergency X-ray Utilization Study) criteria must have clearance of cervical spine done with either an adequate cervical spine X-ray or cervical spine CT scan.

8. Patients with initial GCS <9, should have early anesthetic or critical care physician involved to provide airway management, involve the neurosurgery unit early-on about patients' clinical condition.

9. Resuscitation fluid for traumatic brain injured patients should be limited to Normal Saline or Balanced Salt solution. Use of Hypotonic fluids (e.g. Dextrose water, dextrose-saline) is to be avoided.

10. Ensure adequate pain control using intravenous analgesia. Splint limb fractures, and catheterize patient.

4. IMAGING

1. The primary imaging of choice in traumatic brain injury is a CT scan. However, x-ray is the first line of imaging for adults in whom concomitant spinal injury is suspected. The indication for imaging with CT scan should include chronic outcomes of trauma (such as chronic epidural or chronic subdural clot) in addition to acute primary and immediate secondary assaults. It is important that patient has had initial primary survey (according to ATLS protocol) prior to moving to radiology for imaging.
2. Ensure appropriate monitoring of patient/anticipate need for resuscitation during transfer to and from radiology unit.
3. Use of Skull X-rays is limited in traumatic brain injury. It is not advised that skull x-ray be used to diagnose brain injury.
4. CT scan is indicated within 1 hour of presentation in Accident and Emergency if there is head injury with the following risk factors:
   A. ADULTS
      1. GCS<13 on initial assessment by a trained staff
      2. Open skull fracture or suspected depressed skull fracture.
      3. Focal neurologic deficit (anisocoria, limb weakness, dysphasia, hemifacial weakness).
      4. Post traumatic seizures
      5. More than 1 episode of vomiting.
      6. CSF leaks/ Sign of skull base fracture (raccoon eyes, battle sign)
      7. CT scan is advised within 8hours in patients with GCS 15 but experienced
         i). Loss of consciousness/ Amnesia since incident

         ii). Age >65years

         iii). Dangerous mechanism—pedestrian motor accidents, ejection from the car, fall from height >5meters

         iv). History of bleeding disorders/ use of anticoagulants.

   B. CHILDREN
      1. GCS<14 on initial assessment by a trained staff, for children under 1year old, request CT if GCS <15 on assessment.
      2. Loss of consciousness >5minutes.
      3. Open skull fracture or suspected depressed skull fracture/ tense fontanelle.
      4. Focal neurologic deficit (anisocoria, limb weakness, dysphasia, hemifacial weakness).
      5. Post traumatic seizures
      6. CSF leaks/ Sign of skull base fracture (raccoon eyes, battle sign)
      7. Presence of swelling/bruise >5cm on the head.

8. Perform CT scan if the child has none of the above but, has 1 or 2 of:
    i) Abnormal drowsiness following the incident
    ii) Dangerous mechanism of injury (fall from height/ >3meters, road traffic accident, suspicion of non-accidental injury)
    iii) 3 or more episodes of vomiting

5. MANAGEMENT PLANS

Patients with severe traumatic brain injury (GCS <9) are most optimally managed in a specialized neurotrauma center where neurosurgical and neurocritical care support services are available.

This proposed management plan is aimed at providing framework for care of patients with severe TBI (Traumatic brain injury) and encourage the use of guidelines-based standardized protocols.

Each neurosurgical center/neurosurgeon have the final responsibility for management plan on each patient in their facilities.

A. Treatment Goals
For ease of management, certain clinical parameters need to be maintained as part of goal-directed treatment of severe TBI. Some of these goals are more relevant for patients in the intensive care unit (ICU) setting (e.g., CPP, ICP, PbtO2)

1. Oxygenation: Ensure adequate oxygenation and normocarbia. Aim for sPO2 >95% (pulse oximetry), PaO2>100mmHg and PaCO2-35-45mmHg. Acute hypercarbia is to be avoided during ventilation as it may cause elevations in ICP, likewise hypocarbia should equally be avoided as it may precipitate cerebral ischemia.
It is advised that hyperventilation only be used as a last resolve to reduce ICP, and when used PaCO2 less than 30mmHg should be avoided.

2. Blood Pressure: Prevent hypotension. Aim for Systolic Blood Pressure (SBP)>100mmHg, Mean Arterial Pressures (MAP) >80mmHg and Cerebral Perfusion Pressure (CPP) >60mmHg. Invasive blood pressure monitoring is preferable for dynamic BP monitoring.

3. Temperature: Ensure patient is normothermic (36-38degrees). Efforts to warm resuscitative fluids (especially in children), and active measures to cool patient who are pyretic (antipyretics, ice packs) advised. Therapeutic hypothermia is not advised, as it is associated with worse outcomes.

4. Electrolytes: The goal for electrolytes is to maintain within normal range. Specific attention to the sodium level is important in TBI patients. Hyponatremia must be avoided as this may worsen cerebral edema.

5. Anemia and Coagulopathy: these are relatively common in TBI. Ensure Hb >7g/dl, Platelet> 75,000, INR<1.4

6. Glycemic Control: hyperglycemia and hypoglycemia are detrimental to the outcome of patients with TBI. It is advised that Serum glucose levels be monitored closely in all TBI patients. Aim for range 140-180mg/dl.

7. Nutrition: It is advised that feeding should start as early as possible in patients with severe TBI. Aim to attain basal caloric replacement at least by the 5th day post injury.

8. Antiseizure drug and EEG Monitoring: It is recommended that these drugs should not be commenced till at least one episode of seizure has occurred for low risk TBI patients. They should however be discontinued after 1 week of administration.

   On the other hand, the antiseizure drug should be immediately commenced prophylactically for High risk TBI patients (which include the following):

   - Severe head injury with multifocal cerebral contusions
   - Penetrating brain injury
   - Perforating brain injury
   - Prior seizure history
   - Patients undergoing craniotomy

Hence, for the high-risk group on arrival, the treatment should be as for Early Post-traumatic seizure prophylaxis while for the Low risk group, seizure treatment should follow the guidelines on Late post-traumatic seizures. Choice of route of administration of antiseizure medication could be intravenous or enteral via nasogastric tube depending on which formulation is available. However, use of Intravenous formulations (Phenytoin, Epilim (Sodium valproate), Levetiracetam) are advised in the initial acute phase, this can be changed to oral formulations once enteral nutrition is started. Phenytoin is administered at 20mg/kg loading dose (but 15mg/kg in the elderly) and maintained at 5mg/kg in divided doses. Epilim is given at 15-60mg/kg per day starting at 15mg/kg per day and then increasing dose at 1 weekly intervals. Levetiracetam is administered at 500mg twice daily and

gradually increased to 3000mg per day in divided doses as per need. However, there is currently insufficient evidence to recommend levetiracetam compared with phenytoin regarding efficacy in preventing early post-traumatic seizures and toxicity.

Initial medication for aborting the seizures could be a benzodiazepine (Lorazepam 0.1mg/kg IV at not more than 2mg per minute; Diazepam 0.1mg/kg at not more than 50mg per minute; or Midazolam 0,05mg/kg at not more than 0.01mg per minute). Alternatively, IV Phenytoin (refer to dosage above) or Phenobarbital (up to 20mg/kg IV at not more than 100mg per minute) could be administered to abort the seizures.

Electroencephalography is advised after 48-72hours in patients with persistent impaired level of consciousness, to assess possible non-convulsive seizures or status seizures.

STATUS EPILEPTICUS

This is seizure lasting more than 5 minutes or persistent seizure activity after sequential administration of a first-line and second-line anticonvulsant medication. It is commonly seen in severe head injury with extensive multifocal cerebral contusions and may also occur in seizure disorder patients who sustain severe head injury. The general treatment measure is to clear and secure the airway, and then abort the seizures starting with first-line drugs (lorazepam, diazepam and midazolam), followed by second-line medications (Phenytoin, Fosphenytoin) and then the third-line drugs (Phenobarbital, Sodium valproate or Levetiracetam) in that order. If these fail, other antiepileptics such as Topiramate, Lamotrigine, Carbamazepine may be tried. If it persists, the anaesthetist should then be involved at this stage to intubate and use intravenous agents like Propofol (1-2mg/kg IV at 10mg per minute and maintain at 2 – 10mg/kg per hour). Inhalational anaesthetic may also be used at this stage.

Magnesium Sulphate

This pharmacologic agent is currently recommended only for trauma in the obstetric patient, and particularly for eclamptic patients. It is administered at a dose of 4 – 6g IV loading dose over 15 – 20 minutes.

9. Steroid medication:
   Current emphasis based on evidence is that steroids should not be used in traumatic brain injury. It is of no particular benefit in the management of these patients (level I evidence).

10. Mannitol and Hypertonic saline:
    The main indication for use in TBI is to reduce brain swelling in cytotoxic generalized cerebral edema by its capacity to increase permeability of the blood brain barrier. Other indications include intraoperative control of brain swelling during surgery for TBI (decompressive craniotomy/craniectomy, evacuation of intracranial hematoma collections). They however should not be used in uncorrected hypovolemic shock, functional renal impairment and in patients in whom intracranial haematoma has not first been ruled out with neuroimaging.

    Either 10% or 20% mannitol may be used for those patients who meet the criteria. Intermittent administration rapidly infused intravenously over 15 – 20 minutes are generally more effective than continuous infusion at an effective dose ranging from 0.25g – 1g/kg (level II evidence).

    Euvolemia should be maintained with fluid replacement throughout period of its use and an indwelling urethral catheter is required for close monitoring of hourly urinary output (level III evidence). In case of possibility of renal failure, the serum osmolality should be maintained at not more than 320mOsm/L.

    In polytraumatized / multiply injured patients with excess blood loss and possible imminent hypovolemic shock, ensure optimal fluid preload of the CVS to prevent the dangerous dehydration from mannitol which has capacity to spin off a cascade of toxic systemic injuries.

    Currently available evidence does not allow for any strict recommendations yet for use of Hypertonic saline.

11. Intracranial pressure monitoring:
    A. NON-INVASIVE MONITORING – Most methods (Transocular ultrasound measurement of optic nerve sheath thickness, tympanic membrane displacement and pulsatility) are yet

to be validated and have no guidelines yet for any recommendations for use. The only modality of this form of ICP monitoring is GCS (Glasgow coma score) monitoring which is known to correlate with intracerebral probes.

B. INVASIVE MONITORING - An intracerebral ICP monitoring probe / bolt should be routinely inserted in the following situations:
   - where the ICP cannot be reliably monitored in the ICU (i.e where TBI patients with any possibility of having surgical intervention in case of rising ICP cannot have their GCS properly monitored by ICU staff).
   - for patients with surgical lesions (extradural/subdural hematoma, depressed skull fracture) who satisfy criteria for conservative care
   - for salvageable severe TBI patients after cardiopulmonary resuscitation with an abnormal brain CT (level II evidence) or with normal brain CT (level III evidence) having any 2 or more of the following risk factors:
     a. Age more than 40 years old
     b. Systolic BP less than 90
     c. Decerebrate or decorticate posturing on motor examination

Aim at starting therapy for ICP exceeding 20 – 25mmHg. The ICP monitoring should be discontinued if the ICP remains normal for up to 48 or 72 hours after withdrawal of therapy for elevated ICP.

Neither prophylactic antibiotic nor routine intraventricular catheter exchange has been found to reduce or prevent infection (level III evidence). Hence, to prevent or minimize intracranial sepsis, insertion of the monitor must be done as a strict aseptic procedure. In case of any infection, the device should be removed completely.

B. Surgical Treatment

Indications for emergency surgery after severe head Injury is based on neurologic status (GCS), and findings on CT scan (focal injuries—hematomas, depressed fractures, evidence of mass effect/midline shift). Decision to operate should be individualized on each occasion, after reviewing the patient and the imaging findings.

1. Extradural haematoma (EDH) — Craniotomy / clot evacuation, or in special and dire circumstances, a craniectomy may initially suffice for decompression of patients with acute EDH and GCS <9. Evacuation is recommended if the hematoma is larger than $30cm^3$ in volume and cloth thickness >15mm regardless of a patient's GCS score.
Non operative management may be considered in patients with:

   i. EDH volume $<30cm^3$,
   ii. Clot thickness <15mm and midline shift <5mm
   iii. GCS >9 and no focal neurologic deficits

However, serial CT scans is advised due to high risk of hematoma

enlargement (8-36hours post injury).

2. Subdural haematoma (SDH)—Surgery is indicated for acute SDH > 10mm thickness or associated midline shift >5mm regardless of patients GCS.
   Surgery is also recommended if GCS decreased by 2points from time of injury to admission or patient has pupillary asymmetry or fixed and dilated pupils.

   Non operative management may be considered in patients with acute SDH clinically stable/improving with clot thickness <10mm, midline shift <5mm.

   Patients with reduced GCS being managed non-operatively are better nursed in intensive care unit/high dependency unit.

3. Intracerebral haemorrhage (ICH)—For posterior fossa ICH with significant mass effect (ventricular compression/distortion, or hydrocephalus) surgery is advised.
   Cerebral hemispheric ICH should be considered for surgery if:

   i) volume>50cm^3
   ii) >20cm^3 in frontal or temporal region with midline shift >5mm with patients GCS 9-6

4. Depressed Skull Fracture—Elevation and debridement is recommended for open skull fractures depressed > thickness of the cranium. Surgery should be expedited in cases with suspected dural tear, gross contamination, pneumocephalus or underlying hematoma.
   Use of prophylactic antibiotics should be based on extent of wound contamination and local wound infection pattern.

   Early administration of anticonvulsant is advised to reduce risk of seizures.

   Administration of pneumococcal vaccine is advised if the fracture involve the sinuses with associated pneumocephalus.

5. Penetrating Injury—superficial debridement and primary dural closure is advised to prevent CSF leaks, aggressive debridement and removal of deep foreign bodies(bullets/pellets) not advocated.
   Small entry wounds can be closed in simple closure.

   Use of broad-spectrum intravenous antibiotics is advised

NOTE: Post- traumatic chronic subdural and epidural haematoma should be managed as forms of TBI since they are generally often sequel of TBI.

PRE-HOSPITAL CARE OF SPINAL CORD INJURY

The primary assessment of the patient should follow the ABCD protocol: Airway, Breathing, Circulation, Disability (neurologic status). If the patient has a head injury, is unconscious or confused, or complains of spinal pain, weakness, and/or loss of sensation, then a traumatic spinal injury should be assumed.

1. Allow as little movement of the spine as possible—use of log-roll movements and a backboard for transfer and placement of a rigid cervical collar.
2. Assess the person for spinal injury, by checking if the person:
    - has a reduced level of consciousness
    - has any significant distracting injuries
    - is under the influence of drugs or alcohol
    - has any hand or foot weakness (motor assessment)
    - has altered or absent sensation in the hands or feet (sensory assessment)
    - has a history of past spinal problems, including previous spinal surgery or conditions that predispose to instability of the spine.
3. Carry out full in-line spinal immobilization if any of the above is present or assessment cannot be done.
4. Transport persons with suspected acute traumatic spinal cord injury with full in-line spinal immobilization to major trauma center, in cases in which the person needs an immediate lifesaving intervention—transfer can be made to nearest trauma unit.

INITIAL ASSESSMENT OF SPINAL CORD INJURED PATIENTS IN HOSPITAL ACCIDENT AND EMERGENCY UNITS/TRAUMA CENTERS

The management in the A&E departments should follow the ABCD scheme.

1. Identify and treat life-threatening injuries
2. Continue full in-line spinal immobilization until the extent of injury is assessed.
3. Assessment for cervical spine injury; determine if the patient is at high, low or no risk for cervical spine injury using the Canadian C-spine rule as follows:
    A. the person is at high risk if they have at least one of the following high-risk factors:
        1. age 65 years or older
        2. dangerous mechanism of injury (fall from a height of greater than 1 meter or 5 steps, axial load to the head
        3. paresthesia in the upper or lower limbs

B. the person is at low risk if they have at least one of the following low-risk factors:
    1. involved in a minor rear-end motor vehicle collision
    2. comfortable in a sitting position
    3. ambulatory at any time since the injury
    4. no midline cervical spine tenderness
    5. delayed onset of neck pain
C. the person remains at low risk if they are:
    1. unable to actively rotate their neck 45 degrees to the left and right (the range of the neck can only be assessed safely if the person is at low risk and there are no high-risk factors).
D. the person has no risk if they:
    1. have one of the above low-risk factors and
    2. are able to actively rotate their neck 45 degrees to the left and right.

4. Assessment for thoracic or lumbosacral spine injury is recommended using these factors:

- age 65 years or older and reported pain in the thoracic or lumbosacral spine
- dangerous mechanism of injury (fall from a height of greater than 3 meters, axial load to the head or base of the spine)
- pre-existing spinal pathology, or known or at risk of osteoporosis – for example steroid use
- suspected spinal fracture in another region of the spine
- abnormal neurological symptoms (paresthesia or weakness or numbness)
- on examination:
    - abnormal neurological signs (motor or sensory deficit)
    - new deformity or bony midline tenderness (on palpation)
    - bony midline tenderness (on percussion)
    - midline or spinal pain (on coughing)
- on mobilization (sit, stand, step, assess walking): pain or abnormal neurological symptoms (stop if this occurs).

IMAGING

X-ray is the first line of imaging for any adult in whom spinal injury is suspected. It is recommended that imaging for spinal cord injured patient should be performed urgently, and should be reviewed immediately by adequately trained and skill healthcare personnel.

A. ADULTS

Computed Tomography (CT) Scan is recommended in adults if:

1. a high-risk factor for cervical spine injury on assessment (indicated by the Canadian C-spine rule)
2. a low-risk factor for cervical spine injury on assessment (as indicated by the Canadian C-spine rule) and the person is unable to actively rotate their neck 45 degrees left and right
3. there is a strong suspicion of thoracic or lumbosacral spine injury associated with abnormal neurological signs or symptoms
4. X-ray is recommended as first-line investigation in person with suspected thoraco-lumbosacral (T1-L3) spinal column injury with no neurological signs or symptoms
5. CT scan is recommended if X-ray is abnormal or presence of clinical sign or symptoms of spinal cord injury
6. MRI is recommended, if there is neurological abnormality which could be attributable to spinal cord injury on CT scan

B. CHILDREN

MRI is recommended for children if there is a strong suspicion of:

1. cervical spinal cord injury as indicated by the Canadian C-spine rule and by clinical assessment or
2. cervical spinal column injury as indicated by clinical assessment or abnormal neurological signs or symptoms, or both
3. If criteria for MRI not fulfilled but clinical suspicion remains, X-rays is advocated.
4. It is recommended that X-ray findings be reviewed by a skilled and experienced radiologist
5. X-rays is recommended as first line imaging for suspected thoracolumbosacral injuries with no neurologic signs and symptoms

MANAGEMENT PLAN FOR TRAUMATIC SPINAL CORD INJURED PATIENTS

The care of patients with traumatic spinal cord injury involve intensive medicare and continuous monitoring which are better provided in an intensive care unit/dedicated acute spinal care units. The aim of such intensive care is to reduce systemic and neurologic complications that significantly to survival and prognosis.

A. Respiratory

The goals are

- to avoid hypoxia, enhance clearance of secretions, prevent/decrease atelectasis and prevent pneumonias.
- Access the need for intubation ((increased respiratory rates, rising pCO_2, low pO_2) especially in high cervical injuries
- For ventilated patients the following are recommended:
  --Ventilator Associated Pneumonia (VAP) protocol (oral care 4 hourly, HOB>30°),

  Chlorhexidine oral rinse 15 mL swish and suction 12 hourly

--Cough Assist 4 hourly

--Albuterol 2.5mg/3 mL nebulized 4hourly

--Assess need for respiratory suctioning frequently to avoid mucous plugs

--Early tracheostomy (<7 days post-injury or 4 days after anterior fusion unless other neurosurgical concern)

- For non-ventilated patients:
  --Monitor for need for mechanical ventilation (respiratory failure, intractable atelectasis on CXR, weakening voice, etc.)

  --Incentive Spirometry 1-2 hourly

  --Cough Assist Device every 4 hourly

- Albuterol 2.5 mg/3 mL nebulized 4hourly/prn increased secretions

B. Cardiovascular

The goals are to restore normal hemodynamic parameters and avoid hypotension and bradycardia.

- Aim for Mean Arterial Pressures ≥ 85 mmHg for blunt & incomplete penetrating SCI injury for at least 72hrs (max of 7days post injury)
- Mean Arterial Pressures ≥ 65 mmHg for complete penetrating SCI injury (ASIA A)
- Prevent/Correct hypotension by fluid boluses (Normal Saline), continuous check of fluid status responsiveness recommended to avoid overload.
- Use inotropes (0.05mcg/kg/min) and – titrate to goal MAP: (a) blunt SCI / incomplete penetrating: MAP ≥ 85 mmHg, (b) Complete penetrating SCI: MAP ≥ 65 mmHg (ASIA A)
- If hypotension persistent – check random Cortisol level; if Cortisol < 20 mcg/dL and still on inotropes = start Hydrocortisone 100 mg IV 8hrly
- Bradycardia:
  - assess for presence of mucous plugs
  - Ambu-bag with FiO2 1.0 and suction
  - Atropine 0.5mg IV 1hourly/PRN heart rate < 40 and/or symptomatic
  - If bradycardia persist, discuss with cardiologist for possible pacing

C. Gastrointestinal

The goals are to ensure that

- patient tolerate diet, and maintain or improve nutritional status
- minimize weight loss
- establish scheduled bowel motions while minimizing occurrence of diarrhea and/or constipation

It is recommended that:

- Consultation with a Speech Therapist for swallow is obtained evaluation prior to initiating oral intake in any SCI patient with cervical spinal cord injury, prolonged intubation, tracheostomy, Halo fixation, or after any cervical spine surgery.
- Obtain feeding access and initiate enteral support within 48 hours
- Dietitian consultation for intervention to assess for calorie and protein needs
- Maintain euglycemia (blood glucose < 180 mg/dL)
- Use of stimulant laxatives and prokinetics should be tailored to achieve scheduled bowel motions.

D. Deep Venous Thrombosis (DVT) Prophylaxis

Both mechanical and chemical thrombo-prophylaxis are encouraged:

- Calf compressor devices to bilateral lower extremities while in bed
- Initiate unfractionated heparin on admission - Heparin 5000 units 8hrly (increase 7500 units if BMI ≥ 35)
- Transition to enoxaparin 72 hours' post- operative or immediately if non- operative
- Consider IVC filter placement for high risk patients that are unable to receive chemical prophylaxis

E. Neurology

It is important that the neurosurgeon/experience and skilled healthcare personnel of define level of injury upon initial review, and set a baseline for sensory, motor, & reflex status

- It is recommended that documentation is made of sensory, motor, and reflex status every 24 hours x 3 days
- Neurosurgery/Attending to communicate level of injury to patient / family
- Decompression and Stabilization: the indication for surgery, timing and method of vertebral decompression (open/closed reduction) is to be determined by each consultant neurosurgeon/spine surgeon based on local institution protocol, however early decompression and stabilization in those with significant cord compression with neurologic deficit (<72 hours' post-injury) is advocated.
- Use of Glucocorticoids (Steroids): There is inconclusive evidence on the use of Methylprednisolone in Acute spine cord injury
    1. Use of methylprednisolone is not recommended in patients with moderate/severe Traumatic brain injury as well as traumatic spinal cord injury—as it is associated with increase mortality
    2. The use of methylprednisolone in isolated traumatic spinal is not recommended as standard of care, each consultant can consider it as a treatment option.

MANAGEMENT OF PATIENTS WITH PERIPHERAL NERVE INJURY IN HOSPITAL ACCIDENT AND EMERGENCY UNITS/TRAUMA CENTERS

As for other trauma-related problems, the management in the A&E departments should follow the ABCD scheme. Life-threatening injuries should be identified and treated.

Generally, the armamentarium of the peripheral nerve surgeon includes: (1) the initial history and examination, (2) preoperative electrophysiology, (3) preoperative rehabilitation, (4) longitudinal preoperative clinical and electrophysiological course (i.e. recovery/ no recovery), (5) preoperative radiological assessment, (6) intraoperative anatomic study, (7) intraoperative electrophysiology, (8) operative procedures, and (9) postoperative rehabilitation.
There must be a clear understanding of the involved anatomy of the brachial plexus in each patient, what is uninjured and still viable for nerve transfer repair, as well as available facilities and equipment.

PRE-OPERATIVE EVALUATION

Imaging: Plain-film X-ray, computerized tomography myelogram (CT), magnetic resonance imaging (MRI), ultrasound (US), as well as positron emission tomography (PET) all have their various indications in the management of peripheral nerve problems. Of all these modalities, MRI and CT myelogram are generally the main radiological investigations for diagnosis

Electrophysiology: Electrodiagnostic studies are equally essential, particularly electromyography (EMG) and nerve conduction studies (NCS). When the electrophysiology findings are combined with the longitudinal clinical evaluation of motor recovery, the surgeon can then better decide upon timing and extent of repair required.

Managing each patient's expectations is perhaps the most important part of pre-operative planning and preparation. Patients must be made to understand the limits of the best possible outcome and the possibility that either no improvement at all or limited functional improvement may occur after surgery.

INTRA-OPERATIVE PROTOCOLS
The integrity of the donor nerve is a major determining factor for successful outcomes. Single direct coaptation repair of a donor nerve to the recipient nerve (neurotization repair) without tension is generally considered superior to indirect repair with a cable graft, since only one micro anastomosis is required. The following must be observed to ensure optimal results:

- Only Sharp cut ends to be anastomosed, never ragged ends
- Avoid too many stitches for anastomosis and use glue instead
- Avoid passing the needle through the fascicles
- Ensure good magnification and adequate lighting
- Avoid tension in the repair

- Avoid direct use of suction over graft / site of anastomosis
- Use Fine sutures; interrupted stitches; end-to-end anastomosis
- Aim for shorter graft length
- Aim for autograft of similar size & fascicular pattern

POST-OPERATIVE:

Rehabilitation constitutes the postoperative care until the patient achieves maximal functional and neurological recovery. Once the affected limb can be mobilized, the primary focus should be to prevent development of contractures by passive range of motion exercises

- In early post-op period, avoid tension across joints in the area – by splinting limb (POP back slab, brace etc.) for at least 4 weeks
- After wound healing, active engagement in regular physiotherapy consistently for at least 2 - 3 year.

SUMMARY

The information in the above guidelines reflect the best practices as of now, determined by best evidence provided by clinical trials and research. The information therein, may change as more evidence become available in the field of neurotrauma in future, as such the guideline may be revised.

Thanks.

Dr A. Oseni and Dr C. Onyia

Neurotrauma Standard of Practice Subcommittee

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PROPOSED FRAMEWORK FOR THE SETTING UP OF A TRAUMA REGISTRY FOR NEUROSURGERY IN NIGERIA

The Neurotrauma Committee of Nigerian Academy of Neurological Surgeons (NANS) created three sub-committees including, Neurotrauma Registry Sub-committee, which was saddled with the responsibility of drafting this document.

OBJECTIVES:

1. Define neurotrauma.
2. Setting up a neurotrauma registry in the Nigerian perspective.
3. Continuous data generation.
4. Develop, in collaboration with the other two sub-committees, a national policy on neurotrauma care.
5. Propose a Bill to the National Assembly on all facets of neurotrauma in Nigeria with the passage of a neurotrauma bill.
6. Revision of the National Health Insurance Scheme (NHIS) to include all aspects of the neurotrauma care.
7. Public education and awareness on all aspects of neurotrauma.
8. Structured research to improve neurotrauma care and outcome from available and analysed data.

Definition of Neurotrauma

Trauma to the brain, spinal cord, and/or peripheral nerve(s), and/or their coveringsfrom an externally applied mechanical force.

Setting up a Neurotrauma Registry in the Nigerian Perspective:

A Neurotrauma Registry is proposed to be set up in collaboration with NANS based on the peculiarities of neurosurgical practise in Nigeria.

1. Institutional/Centre-based Neurotrauma Registry:
   This will involve all centres (public and private) in Nigeria with, at least, one consultantneurosurgeon practising in the centre.

   The most senior consultant neurosurgeon in these centres will be in charge of supervising and co-ordination of activities.

   All these centres will collate data of all neurotrauma patients and subsequently submit them 3-monthly to their designated regional neurotrauma registries that will be co-ordinated by the most senior consultant neurosurgeon in those regional centres.

2. Regional Neurotrauma Registry:
   Data from institutional registries are, thereafter, uploaded to the regional neurotrauma data for storage, and will be subsequently within one week, uploaded on the National Registry, co-ordinated by the National Co-ordinator in collaboration with all the six Regional Co-ordinators for a quarterly collation, analysis and audit.

The proposed Institutional/Centre-based Registries, Regional Registries and National Registry are:

1. All centres (public and private) in Nigeria with at least one consultant neurosurgeon practising in the centre. To verify the authenticity of these centres, we suggest that we request for the

names, postal addresses, and heads of neurosurgery (with their contact phone numbers – preferably WhatsApp contact phone numbers, and Email addresses) of these centres from the NANS executives

2.Regional Centres and Regional Co-ordinators:

- South- West: Lagos University Teaching Hospital, Lagos (led by Dr OB Bankole).
- South-South: University of Benin Teaching Hospital, Benin City (led by Dr DO Udoh).
- South- East: Nnamdi Azikiwe University Teaching Hospital, Nnewi (led by Prof. JKC Emejulu).
- North- West: Usmanu Danfodiyo University Teaching Hospital, Sokoto (led by Prof. BB Shehu).
- North -Central (Including the Federal Capital Territory): National Hospital, Abuja (led by Dr R Mahmud).
- North- East: University of Maiduguri Teaching Hospital, Maiduguri (led by Dr U Babagana).

3.National Registry:

- University College Hospital, Ibadan (led by Prof. MT Shokunbi).

Continuous data generation:
This will involve data entry form/broadsheets (paper/hard copy versus electronic/soft copy – both proposed) and data entry/dissemination system.

1. Data Entry Form/Broadsheet:
   Some proposed data to be collected from time of injury until death or discharge from the hospitals include:
   - Patients' demographics.
   - Pre-hospital and hospital assessment and care.
   - Neurotrauma cause.
   - Injury severity.
   - Patients' outcomes (Uniform and collectively accepted outcome scales should be adopted; Glasgow outcome scale and Frankel scale proposed for head and spinal injuries respectively).
   - Follow-up after discharge for as much as possible for up to 5years.

   Two charts are proposed:
   - In-hospital (for data while the patients were on admission).
   - Follow-up (for data after the patients have been discharged).

Proposed data entry form/broadsheet (both for In-hospital and Follow-up) to follow:

In-hospital Sheet

Name of Institutional or Centre-based/Regional Centre/National Registry

Postal Address:

Phone Number (WhatsApp Preferably):

Email:

Date:

S/No	Name	Age	Sex	Hospital Number	Admission Date	Diagnosis-Provisional/Definitive	Relevant Radiological Investigation Findings	Treatment Summary	Discharge Date	Outcome	Consultant
1.											

Patients' Summary of Head Injuries

Ward ↓ and →	Number of Patients	Sex ↓ and →	Number of Patients	Consultant(s) ↓ and →	Number of Patients
		Male			
		Female			
		TOTAL →			
		Age Bracket ↓ and →			
TOTAL →		TOTAL →		TOTAL →	

Patients' Summary of Spinal Injuries/Peripheral Nerve Injuries

Ward ↓ and →	Number of Patients	Sex ↓ and →	Number of Patients	Consultant(s) ↓ and →	Number of Patients
		Male			
		Female			
		TOTAL →			
		Age Bracket ↓ and →			
TOTAL →		TOTAL →		TOTAL →	

Patients' Summary of Neurotrauma (Including Head, Spinal, and Peripheral Nerve Injuries)

Ward ↓ and →	Number of Patients	Sex ↓ and →	Number of Patients	Consultant(s) ↓ and →	Number of Patients
		Male			
		Female			
		TOTAL →			
		Age Bracket ↓ and →			
TOTAL →		TOTAL →		TOTAL →	

Follow-up Sheet

Name of Institutional or Centre-based/Regional Centre/National Registry

Postal Address:

Phone Number (WhatsApp Preferably):

Email:

Date:

S/No	Name	Age	Sex	Hospital Number	Admission Date	Diagnosis-Provisional /Definitive	Relevant Radiological Investigation Findings	Treatment Summary	Discharge Date	Outcome	Consultant
1.											

Patients' Summary of Head Injuries

Ward ↓ and →	Number of Patients	Sex ↓ and →	Number of Patients	Consultant(s) ↓ and →	Number of Patients
		Male			
		Female			
		TOTAL →			
		Age Bracket ↓ and →			
TOTAL →		TOTAL →		TOTAL →	

Patients' Summary of Spinal Injuries/Peripheral Nerve Injuries

Ward ↓ and →	Number of Patients	Sex ↓ and →	Number of Patients	Consultant(s) ↓ and →	Number of Patients
		Male			
		Female			
		TOTAL →			
		Age Bracket ↓ and →			
TOTAL →		TOTAL →		TOTAL →	

Patients' Summary of Neurotrauma (Including Head, Spinal, and Peripheral Nerve Injuries)

Ward ↓ and →	Number of Patients	Sex ↓ and →	Number of Patients	Consultant(s) ↓ and →	Number of Patients
		Male			
		Female			
		TOTAL →			
		Age Bracket ↓ and →			
TOTAL →		TOTAL →		TOTAL →	

The above charts are proposed to be in Microsoft Excel format with a password. To ensure anonymity, a coding/retrieval format is also proposed which will involve the coding of the biodata of all patients, and providing the software resource for decoding or cross-referencing if there be need.

Coding protocol should be uniform all over the country, but each centre and region should additionally maintain a method of decoding the scrambled data.

Regional centres should maintain both serial data capture of all neurotrauma cases from the individual centres all over the country, as well as a backup record of data in separate files according to centres.

National registry should adopt a dual data capture centre as above.

2. Data Entry/Dissemination System:
   The head of each centre will co-ordinate collection andcollation of the above data in paper/hard copy and electronic/soft copy (using Microsoft Excel) formats to generate individual centre data. The hard copy will be sent to the postal address of the regional centre while the soft copy will be sent to the Email address of the regional centre at 3-monthly intervals. Files of hard and soft copies are advised to be kept in each centre for backup and future references.

   The regional officer will then co-ordinate the collection and collation of data receivedfrom centres in the region in paper/hardcopy and electronic/soft copy (using Microsoft Excel) formats to generate regional data. The hard copy of the regional data will be sent to the postal addresses of the centres in the region and the national headquarter while the soft copy of the regional data will be sent to the Email addresses of the centres in the region and the national headquarter at 3-monthly intervals. The regional officer should also send hard copies and soft copies of received data from the individual centres to the national headquarter. Files of hard and soft copies are advised to be kept in each regional centre for backup and future references.

   The head of the national headquarter will co-ordinate the collection and collation of data received from the 6regions in Nigeria in paper/hard copy and electronic/soft copy (using Microsoft Excel) formats to generate national data. The hard copy of the national data will be sent to the postal addresses of the individual centres in Nigeria and the 6regional centres while the soft copy of the national data will be sent to the Email addresses of the individual centres in Nigeria and the 6regional centres in Nigeria yearly. Files of hard and soft copies are advised to be kept in the national headquarter for backup and future references.

To generate this template, the sub-committee accessed some neurotrauma registry models and a summary of some quotes attached to them, viz:

1. Global Neurotrauma Registry
   "One of the key objectives of the NIHR Global Health Research Group on Neurotrauma is the establishment of a global neurotrauma registry. This will be implemented in collaboration with the World Federation of Neurosurgical Societies (WFNS).

   The registry will map the pre-hospital, acute in-hospital, and post-acute care of TBI patients and will be used for defining the contemporary case mix and outcomes of TBI patients. The establishment of a registry is a critical element of the long-term sustainability of Global

Neurotrauma efforts, as it will be utilised by clinicians in local quality improvement projects and research.

The provisional start date for this project is September 2018.

More information will be added soon."

2. Hawaii Neurotrauma Registry Project

"The Hawaii Neurotrauma Registry Project (HNTR) recently entered its fourth year of work in the area of neurotrauma injuries (stroke, traumatic brain injury, spinal cord injury). HNTR is funded by the State of Hawaii Department of Health, Developmental Disabilities Division, Community Resources Branch and is administered by the Pacific Disabilities Center. The project's three main goals are: 1) enroll as many Hawaii residents of all ages with neurotrauma injuries into the Registry (which consists of taking a survey); 2) educate the public about neurotrauma injuries; and 3) provide an information and referral service for all residents with these injuries, regardless of whether they choose to take the survey or not.

The information collected fills a gap in knowledge. Through the State's excellent surveillance system, valuable information is gathered on neurotrauma injuries. The HNTR survey takes it a step further. It seeks to understand what happens when individuals leave the hospital or care facility. What challenges do they face? What are their needs? This information will allow the Department of Health to identify needed community supports and services, educate service providers, and develop safety and prevention plans and policies."

"In the long term, a registry may lead to:

- ❖ Better support services
- ❖ Changes in legislation
- ❖ New research on neurotrauma"

3. A Ugandan Model

"The electronic hospital-based TBI registry is designed through a collaborative approach to capture comprehensive, yet context specific, information on each TBI case, from the time of injury until death or discharge from the hospital. It includes patients' demographics, pre-hospital and hospital assessment and care, TBI causes, injury severity, and patient outcomes. The registry in Uganda will open the opportunity to replicate the process in other similar context and contribute to a better understanding of TBI in these settings, and feed into the global agenda of reducing deaths and disabilities from TBI in low-and middle-income countries."

4. A Malawian Model

*A collaboration between University of North Carolina (UNC) with Kamazu Central Hospital (KCH) in Lilongwe, Malawi.

"In 2008, after obtaining IRB approval, the UNC Department of Surgery began a trauma registry, which includedhead injury data pertinent to neurosurgery. Variablescollected relevant to the characterization of headinjury include baseline demographics, injury mechanism, transfer status, disposition from the emergency room, admission status, admission vital signs, mortality, and Glasgow Coma Scale (GCS) score. While this collection began with simple demographics, additional variableswere added as data collection methods improved."

5. University College Hospital, Ibadan Model
   This involved all patients admitted weekly and the status of the patients on admission (All patients were not neurotrauma patients). Data (in a tabular form) included name of the patient, age, sex, hospital number, admission date, diagnosis, current status, and the managing consultant.

6. An Indian Model
   "A structured reporting system which is based on a uniform template will permit uniform data collection and future statistics and will facilitate and validate independent or comparative audit of performance and quality of care. The successful establishment of a multi-centre registry depends on the development of a concise data entry form, data entry system, and data analysis to continuously maintain the registry."

7. Another Ugandan Model
   "We used a prospective neurosurgical registry based on Research Electronic Data Capture (REDCap) to systematically collect variables spanning 8 categories."

   "A total of 60 variables were tracked in the registry and divided into 8 categories: demographics, patient baseline and risk factors of in-hospital mortality, clinical assessment, diagnostics, management, care continuum, complications, and discharge status."

8. Another Indian Model
   "The aim of present article is to share our experiences and lessons learned from a pilot study which was conducted to collect data to serve as a model in establishing a multi-center registry on traumatic brain injury patients."
   "Variables were identified as per the international norms and the data points were selected which included demographic details, pre-hospital characteristics, clinical details in emergency room, injury details, course during hospital stay, treatment and disposition."

Based on the above models, the sub-committee adopted models 1 to 5 above in a hybrid, viz:
1. Global Neurotrauma Registry.
2. Hawaii Neurotrauma Registry Project.
3. A Ugandan Model.
4. A Malawian Model.
5. University College Hospital, Ibadan Model.

Structured research to improve neurotrauma care and outcome from available data:
Members ofNANS, Neurotrauma Committee, and Neurotrauma Registry Sub-Committee can key into the data collated for research, after appropriate permissions.We suggest that if anyone wants to use the data collated from the registry for research, a written application for approval must be submitted to the head of the individual centres, regional officers, and the head of the national headquarter. Following approval by all of them, the research can only proceed after issuance of an official approval letter/certificate duly signed by the head of the national headquarter especially for regulatory and ethical basis.

Public education on neurotrauma:
This is capital intensive, but very important. Efforts should be made to educate the public about head and spinal injuries. The modalities include using various social media, newspapers, television stations, and radio stations.

Making recommendations for legislation in Nigeria:
Conclusive decisions based on the available analysed data can be used to influence laws that will curb the menace of headand spinal injuries in Nigeria. This will involve sending available data (from centres/regions/national headquarter) and recommendations to policy makers in government, with approval and by the head of the national headquarter, including:

1. The President of the Federal Republic of Nigeria.
2. The Federal Ministry of Health.
3. The Ministries of Health in all the States of Nigeria.
4. Senate Committee on Health.
5. House of Representatives Committee on Health.
6. The Governor of all the States in Nigeria.
7. House of Assembly Committee on Health of all the states in Nigeria.
8. Any other portal recommended.

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- Prof. Emejulu JKC

and

- Dr Ekweogwu OC

Neurotrauma Registry Sub-committee

Guidelines for Neurotrauma Fellowship training and Research

1. Introduction
2. Program overview
3. Centre Requirements
4. Trainers' requirements
5. Trainees' fellowship responsibilities
6. Eligibility /application requirements
7. Program details

1. Introduction:

Neurotrauma is a critical public health problem that deserves the attention of the world's health community. Brain and spinal injuries cause enormous losses to individual, families and the society at large. These also result to death and impairments leading to permanent disabilities.
In Nigeria, there is a lack of data in the prevalence of Neurotrauma. However, Neurotrauma constitutes over 60% of Neurosurgical and /or trauma patients seen in our accident and emergencies or trauma centres.

Emejulu et al. reported 88% and 8.1% cases of head and spinal trauma respectively out of 1055 neurosurgical cases managed over a 30-month period.

2. Program overview: This program is designed to train Neurosurgeons with FMCS/FWACS or its equivalent, who plan to pursue a clinical (fellowship) and academic (PhD) career in trauma research and trauma neurosurgery.

3. Centre requirements

3.1 Basic Requirements (Compulsory):

A. Centres should be in a well-structured hospital setting with neurosurgical beds (beds set aside for neurosurgical patients care only; at least 20 beds dedicated to Trauma)
B. Centres should be in an institution with other supportive service essential for neurosurgical care or easy access to such services in a nearby hospital. Services like Medicine, Surgery, Paediatrics, Pathology, Radiology, Obstetrics and Gynaecology, Ophthalmology, Otolaryngology, Urology, Orthopaedics, Anaesthesia, and Neurology.
C. Centres should either have onsite facilities or a facility within the town for:
   i. Angiography
   ii. CT and MRI

D. Centres should have access to an Intensive care unit with
   i. Facilities for mechanical ventilation and cardiorespiratory monitoring
   ii. Facilities for central and arterial pressures monitoring
   iii. An experienced and dedicated neuro-intensivist per day (either at consultant or senior resident level)
E. Centres with dedicated Neurosurgical Operating suite equipped with:
   i. Operating table / Head holder
   ii. Unipolar and bipolar coagulating units
   iii. General cranial and spine neurosurgical instruments
   iv. Microsurgical instruments for cranial surgeries
   v. Magnification (operating microscope)
F. Centres with trained nurses in neurosurgical inpatient and operating rooms services.
G. Centres with easy access to a library with current texts and journals for access to literature.
H. Centres well-known for publications on Neurotrauma i.e. at least 10 institutional based publication
I. Hospital paid position for fellows at a salary grade of at least a Senior Registrar 1.

3.2 Other suggested equipment (not compulsory)

i. Neurophysiologic intraoperative/ICU monitoring equipment: EEG, EMG, evoked potentials, intracranial pressure monitoring.
ii. Neuronavigation system
iii. Complex spine instrumentation (at least for pedicle screw insertion and lateral mass screw insertion) for trauma
iv.

4. Trainers' requirements

a) One of the trainers must have had formal fellowship training in Neurotrauma.
b) One of the trainers must have expertise in complex spine instrumentation (optional).
c) One of the trainers must be more than 10 years post qualification.

5. Trainees' fellowship responsibilities

A. Call responsibilities: At least 2 in-hospital 2nd on call and two 3rd on-call (home call) monthly (4 calls per month)
B. Leading resident's ward rounds at least once weekly
C. Conducting resident teaching session at least once weekly
D. Write one published paper at the end of a one year or 6-month fellowship

6. Trainees' eligibility/application requirements

A. Medical degree from Medical and Dental Council of Nigeria accredited schools or Medical Schools on WHO directory.
B. Specialty certification (or Eligibility to sit exam as evidence by signed certificate of training with completion of required training) of West African College or National Postgraduate College
C. Statement of purpose indicating interest in Neurotrauma
D. 2 reference letters
E. CV

7. Program Details:

The Program is Clinical and Research based, located at accredited centres.
These include supervised training experience in surgical, medical and research areas, covering aspects like emergency care, surgical care, intensive care and rehabilitation support of Neurotrauma patients.
Also, Personal research project through the available resources within all the facilities that participate in the program.

Duration: 12 months
Clinical work: 9 months
Research: 3 months

Fully devoted 9-month training to treat acute and chronic neurosurgical disorders related to cranial and spinal Neurotrauma, including closed and penetrating head injuries, diffuse axonal injuries, brain oedema, intra cerebral traumatic haemorrhage, vault cranial fractures, etc.
An extensive educational experience in the care of these patients will be sustained, including comprehensive and multidisciplinary management, performance of surgical procedures and integration of surgical therapies with neuro-intensive care clinical management. Clinical rounds and teleconferences will be scheduled weekly in order to discuss several cases.

During the research part of the program, the fellow will be devoted to 3 months research scholarship to participate in advanced research activities, including participation in clinical rounds and analysing advanced neuro-monitoring devices for trauma care. Participation in the elaboration of articles for biomedical journal articles and participation in the Annual NANS meeting or any chosen international Neurosurgical/Neurotrauma meeting during which the Fellow will present an abstract of his/her work. The fellow is also encouraged to publish an article in a journal. If the fellow wishes to have a PhD, he can use this period to apply to the University, chose his supervisor and write his proposal.

Certification: The fellow shall obtain a "Certificate of Fellowship in Neurotrauma" with or without PhD at the end of the program.

Reference:

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- Based on WFNS fellowship guideline