

Joint Theater Trauma System Clinical Practice Guideline

MANAGEMENT OF PATIENTS WITH SEVERE HEAD TRAUMA

Original Release/Approval	3 MAR 2005	Note: This CPG requires an annual review.	
Reviewed:	16 MAY 14	Approved:	16 JUN 14
Supersedes:	Management of Patients with Severe Head Trauma 7 Mar 2012		
<input type="checkbox"/> Minor Changes (or)	<input type="checkbox"/> Changes are substantial and require a thorough reading of this CPG (or)		
<input checked="" type="checkbox"/> Significant Changes:			

1. **Goal.** To provide guidelines and recommendations for the treatment and management of combat casualties with severe head injuries.
2. **Background.**
 - a. Severe traumatic brain injury (TBI) patients are those comatose patients with Glasgow Coma Scores (GCS) of < 9.
 - b. Currently, definitive neurosurgical care is available at the Bagram Echelon/Role III facility in Afghanistan.
 - c. Multiple trends have been observed since 2003, warranting the standardization of care for these casualties.
 - 1) There is a sizeable body of foundational literature from military trauma centers confirming that coalition casualties with severe closed and penetrating brain injuries from OIF and OEF who received timely and aggressive neurosurgical and neuro-critical care interventions had favorable outcomes.¹⁻³
 - 2) A subsequent independent study confirmed the validity of the previously observed favorable outcomes by comparing combat casualties with isolated severe brain injuries to matched civilian counterparts.⁴
 - 3) Positive outcomes are achieved through a combination of rapid evacuation from the battlefield, timely neurosurgical intervention, meticulous critical care, and a dedicated rehabilitative effort that often continues for months. Of particular note, an unprecedented proportion (32–38%) of the worst combat casualties with a presenting GCS of 3 to 5 are able to live independently at 2 years.⁵⁻⁶
 - d. All Coalition casualties with any penetrating head injury, open skull fracture, moderate (GCS 9–13) or severe (GCS 3–8) TBI should be referred to a facility with neurosurgical capability⁷. Coalition forces with GCS 14–15 who do not clear within 24 hours evaluation may require transfer for formal evaluation by a neurologist or neurosurgeon.
 - e. Mild TBI management is guided by Department of Defense Instruction 6490.11 (published 18 September 2012). DoDI 6490.11 is posted on the Joint Trauma System website.
 - f. Host Nation patients with GCS 14–15 should be managed locally and should not be transferred to Level III facilities unless transfer is first discussed and coordinated with the receiving neurosurgeon or Trauma Director.
3. **Evaluation and Treatment** (Modified where appropriate from the “Guidelines for the Management of Severe Traumatic Brain Injury.”⁸)

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- a. Address life-threatening injuries and begin resuscitation using ATLS protocols.
 - 1) Normal saline is the preferred crystalloid solution for resuscitation of patients who do not require massive transfusion.
 - 2) Blood products should be used aggressively in accordance with damage control resuscitation CPG.
 - 3) Albumin and Hespan should be avoided in patients with TBI.⁹
 - 4) Coagulopathy must be aggressively corrected in patients with intracerebral hemorrhage.¹⁰ ROTEM or TeG directed resuscitation and coagulopathy correction is highly encouraged if available. Consider recombinant Factor VIIa for life threatening intracranial bleeding.
 - 5) **Normoventilation with a goal PaCO₂ of 35-40 should be maintained.**
 - 6) Antibiotics are unnecessary for isolated closed head injuries. Casualties with open head injuries should receive Cefazolin 2 gm IV q6-8 hrs or Clindamycin 600 mg IV q 8h at the first available opportunity. The current recommended duration of treatment is 5 days or until cessation of CSF leakage. For additional coverage, consult the current Infection Control CPG (updated April 2012) or the local hospital antibiogram.
 - 7) **Do not use steroids.** Steroids provide no benefit to head injured patients and have been proven to worsen outcomes in patients with severe head injury.
- b. Avoid hypotension and hypoxemia through aggressive resuscitation.
 - 1) Keep SBP > 90 mm Hg.
 - 2) Keep SaO₂ > 93%.
- c. Document serial neurological examinations.
 - 1) GCS.
 - 2) Pupil size and reactivity.
 - 3) Presence or absence of motor weakness, or abnormal response (posturing).

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- d. If possible, for casualties transferring to Role III facilities with neurosurgical capability, avoid medications that cause long-lasting sedation or paralysis. Neurosurgeons at these sites will examine the casualty upon arrival. **However, at no time should medication selection override the need to safely transport the casualty.**
- 1) Vecuronium is preferred for paralysis.
 - 2) Propofol is preferred for sedation.
 - 3) **Intermittent administration of narcotics is preferred over continuous infusions.**
- e. Treat elevated intracranial hypertension if GCS < 9, asymmetric motor posturing, unilateral or bilateral fixed, dilated pupil, deteriorating level of consciousness.
- 1) Initiate 3% Saline Protocol (see [Appendix B](#)).
 - 2) Optimize pO₂ **and** pCO₂ (pO₂ > 80 mm Hg, pCO₂ 35–40 mm Hg).
 - 3) Avoid/rapidly treat hypotension.
 - 4) Elevate head of bed (may keep patient flat in the setting of suspected spine injury and use reverse Trendelenburg position).
 - 5) Ensure adequate pain control and sedation.
 - 6) **Patients with moderate TBI who deteriorate and those with severe TBI should receive 3% saline per protocol ([Appendix B](#)) enroute to the Role III. If further deterioration occurs or if the patient shows signs of herniation (pupillary dilation, hypertension and bradycardia, progression to decerebrate posturing)** consider using Mannitol 1g/kg bolus IV, followed by 0.25g/kg rapid IV push q4hrs. 23.4% HTS saline may also be considered as an alternative to Mannitol if available and may be preferred in patients with hypotension or under-resuscitation.¹¹ Bolus 30 mL IV administered over 10-15 min.
- Note: Do not use Mannitol in hypotensive or under-resuscitated casualties.**
- f. Antiepileptic medications for seizure prophylaxis:
- 1) Indicated for all patients with intracranial hemorrhage, penetrating brain injury, and seizure activity following the injury, or a GCS < 9.
 - 2) Phenytoin, fosphenytoin, or levetiracetam¹² are all acceptable parenteral (IV) medications for seizure prevention.
 - 3) Discontinue after seven days if there is no penetrating brain injury, no prior seizure history, and no development of seizures following the injury.
- g. See attached tables for a concise description of salient points for the management of severe TBI patients.
- h. NOTE: In the CENTCOM AOR, DO NOT implant skull flaps removed during craniectomy on US military patients into the abdominal wall or other structure. Skull reconstruction will be performed in CONUS facilities at the appropriate time using synthetic materials.

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- i. Indications for ICP monitor or ventriculostomy placement include GCS < 9 with intracerebral hemorrhage OR GCS < 9 without intracerebral hemorrhage but with two of the following: age > 40, posturing, or hypotension. In addition, moderate TBI patients (GCS 9-12) who will have a prolonged period when they will be unevaluable (prolonged surgical procedure or CCATT movement out of theater) should undergo placement of ICP monitor or ventriculostomy.⁷ It should be anticipated that patients will require sedation and/or paralytic for transport in many cases, therefore the threshold for placing ICP monitor prior to transport should be low in patients where intracranial hypertension is suspected or anticipated.

4. Performance Improvement Monitoring.

a. Intent (Expected Outcomes).

- 1) Keep SBP > 90 mmHg, MAP > 60 and SaO₂ > 93% to prevent secondary brain injury.
- 2) Steroids are not used on head injury patients.
- 3) Hourly documentation of ICP/ CPP and ventriculostomy output documented in medical record.
- 4) Patients in whom neurological status cannot be monitored clinically and patients with severe TBI will have ICP or ventriculostomy placed prior to transport out of theater.
- 5) Head CT completed within 4 hours of injury for moderate and severe TBI (may require patient transfer for CT).
- 6) Antibiotics will be administered to patients with open head injuries per 3.a.6. above (as outlined in Infection Control CPG).

b. Performance/Adherence Measures.

- 1) SBP >90, MAP >60, and/or SaO₂ >93% documented upon discharge.
- 2) Steroids were not administered.
- 3) Neurological assessment and documentation of ICP/ CPP and ventriculostomy output were recorded hourly in the ICU.
- 4) Patients in whom neurological status cannot be monitored clinically, and patients with severe TBI had ICP or ventriculostomy placed prior to transport out of theater.
- 5) Patients with moderate to severe TBI had head CT performed.
- 6) Patients with open skull fractures received prophylactic antibiotics.

c. Data Source.

- 1) Patient Record
- 2) Department of Defense Trauma Registry (DoDTR)
- 3) ICU flow sheet
- 4) Neurologic assessment flow sheet

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d. System Reporting & Frequency.

The above constitutes the minimum criteria for PI monitoring of this CPG. System reporting will be performed annually; additional PI monitoring and system reporting may be performed as needed.

The system review and data analysis will be performed by the Joint Theater Trauma System (JTTS) Director, JTTS Program Manager, and the Joint Trauma System (JTS) Performance Improvement Branch.

5. Responsibilities. It is the trauma team leader's responsibility to ensure familiarity, appropriate compliance and PI monitoring at the local level with this CPG.

6. References.

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3. Ecker RD, Mulligan LP, Dirks M et al. Outcomes of 33 patients from the wars in Iraq and Afghanistan undergoing bilateral or bicompartamental craniectomy. *J Neurosurg*. 2011 Jul;115(1):124-9.
4. DuBose, JJ, Barmparas G, Inaba K et al. Isolated Severe Traumatic Brain Injuries Sustained During Combat Operations: Demographics, mortality outcomes, and lessons to be learned from contrasts to civilian counterparts. *J Trauma*. 2011;70:11-18.
5. Nakase-Richardson R, McNamee S, Howe LL, Massengale J et al. Descriptive Characteristics and Rehabilitation Outcomes in Active Duty Military Personnel and Veterans with Disorders of Consciousness With Combat and Non-Combat Related Brain Injury. *Arch Phys Med Rehabil*. 2013 Jun 25
6. Weisbrod AB, Rodriguez C, Bell R et al. Long-term outcomes of combat casualties sustaining penetrating traumatic brain injury. *J Trauma Acute Care Surg*. 2012 Dec;73(6):1525-30
7. Guidelines for Field Management of Combat-related head trauma. *Emergency War Surgery Handbook*, 2004.
8. Brain Trauma Foundation. Guidelines for the Management of Severe Traumatic Brain Injury, 3rd Edition. *J Neurotrauma*. 2007;24(S1):S1-106.
9. SAFE Study Investigators. Saline or albumin for fluid resuscitation in patients with traumatic brain injury. *NEJM*. 2007;357:874-84.
10. Talving P, Benfield R, Hadjizacharia P, Inaba K, Chan LS, Demetriades D. Coagulopathy in severe traumatic brain injury: A prospective study. *J Trauma*. 2009;66:55-62.

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11. Kerwin AJ, Schinco MA, Tepas JJ, et al. The use of 23.4% hypertonic saline for the management of elevated intracranial pressure in patients with severe traumatic brain injury: a pilot study. *J Trauma*. 2009 Aug;67(2):277-82.
12. Szaflarski JP, Sangha KS, Lindsell CJ, Shutter LA. Prospective, randomized, single-blinded comparative trial of intravenous levetiracetam versus phenytoin for seizure prophylaxis. *Neurocrit Care*. 2010 Apr;12(2):165-72.

**Approved by CENTCOM JTTS Director,
JTS Director and CENTCOM SG**

Opinions, interpretations, conclusions, and recommendations are those of the authors and are not necessarily endorsed by the Services or DoD.

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APPENDIX A

MONITORING & LABS	GENERAL INDICATIONS*
INTRACRANIAL PRESSURE (ICP)	Glasgow Coma Score of 3-8 with an abnormal CT scan (hematomas, contusions, edema, or compressed basal cisterns) <i>or</i> 2 or more of the following adverse features are present in a patient with severe head injury and a normal head CT scan: (Age > 40 yrs, Unilateral or bilateral motor posturing, systolic blood pressure, < 90 mmHg).
ARTERIAL LINE	Any head trauma that requires tracheal intubation and/or for other medical indications.
CENTRAL VENOUS PRESSURE	When ICP or CPP management requires anything beyond simple measures and/or for other medical indications. <i>Trendelenburg position will raise ICP. Line site of choice is SCV.</i>
EXHALED CO₂	Desirable when active measures are required to control ICP. Correlate to PaCO ₂ initially/periodically.
NEUROIMAGING	Non-contrast head CT upon admission then within 24 hours after admission (or earlier to document stability of the bleed). Additional scans obtained as indicated (e.g. clinical deterioration).
LABS	ABG, CBC, Chem 10, TEG, PT, PTT, and INR <i>at least</i> q8 hrs during the acute phase.
GENERAL MANAGEMENT PRINCIPLES*	
PHILOSOPHY	<ul style="list-style-type: none"> <input type="checkbox"/> Maintain continuous communication between the care teams. <input type="checkbox"/> Maintain the patient in a “hyperosmolar-but-euvolemic” state with adequate oxygen carrying capacity and a constant substrate delivery via adequate cerebral perfusion pressure (CPP) of >60mm Hg. <input type="checkbox"/> Aggressively avoid hypotension, hypoxemia, fever (>99 F), hyponatremia and other CNS insults. <input type="checkbox"/> The longer the ICP is elevated (> 20), and the MAP & CPP are low (< 60), the worse the outcome! <input type="checkbox"/> Brain injury is heterogeneous amongst patients and the process is dynamic: Treatment and management goals must be tailored accordingly
RESUSCITATION FLUID	Normal or 3% saline.
MAINTENANCE FLUID	Normal saline
SEDATION	Propofol 1 st choice up to 72°. Other short-acting agents (Fentanyl, Versed) upon discretion of SICU or neurosurgical staff. Typical ICU Propofol sedation dose range: 20-75 mcg/kg/min
ULCER PROPHYLAXIS	All patients.
DVT PROPHYLAXIS	Recognize high DVT risk in traumatic brain injury patients. Intracranial neurosurgical procedures: Sequential Compression Device (SCD) with or without Graduated Compression Stocking (GCS); High Risk neurosurgery patients: SCD and/or GCS; OK to use Lovenox following stable CT scan in consultation with neurosurgeon.

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SEIZURE PROPHYLAXIS	Prophylactic anti-epileptic treatment is optional and is maintained for 7 days if no seizure activity is documented. Phenytoin, fosphenytoin and levetiracetam may all be used as seizure prophylaxis. Treat acute seizure with Lorazepam 1-2 mg IV or Midazolam 5-10 mg IV followed by loading dose of Phenytoin 20 mg/kg infused at <50 mg/min or Fosphenytoin 20 PE (Phenytoin equivalent)/kg infused at <150 PE/min. The daily dose thereafter is 300 mg Phenytoin or 300 PE Fosphenytoin q HS or may be divided TID. Keppra (Levetiracetam) can be considered in lieu of Phenytoin with 20 mg/kg loading dose followed by 500 mg IV BID.		
ANTIBIOTICS	If using antibiotic impregnated ventriculostomy, then no IV prophylactic antibiotics required. Otherwise, Ancef 1 gm IV TID while ventriculostomy in place only (neurosurgeons' discretion). For all penetrating head trauma, use cefazolin (see 3,a. 6) above.		
NURSING	Hourly neurologic assessments. Document ICP/CPP and ventriculostomy output. Notify physician of all pertinent changes.		
STEROIDS	Steroids are <i>not</i> recommended for head or spine trauma and should not be used.		
NUTRITION	Enteral feeding should be begun as soon as it is safe to do so. <i>Avoid agitation/ ICP during nasal or oral tube placement.</i> Full enteral nutritional goal ≤ 7 days.		
General Management Goals (Goals may be individualized / altered by faculty according to specific patient requirements)*			
NEUROLOGIC	ICP	< 20 mm Hg	See page 2
	CPP	> 60 mm Hg	
HEMODYNAMIC	Mean BP	Maintain to avoid ↓BP	<input type="checkbox"/> Hypotension (SBP < 90mmHg) worsens mortality <input type="checkbox"/> Provide a rapid physiologic resuscitation
	CVP	> 5 mm Hg	
PULMONARY	SpO2%	> 93%	Aggressive avoidance of hypoxemia
	PaCO ₂	35 – 40 mmHg in first 24 hrs/	Avoid <i>routine</i> hyperventilation
HEMATOLOGIC	INR	≤ 1.3	Fresh frozen plasma
	Platelets	≥ 100,000/mm³	Platelets
	TEG	Normalized values	As indicated by results
METABOLIC	Glucose	> 80 < 150 mg/dl	Have low threshold for insulin drip
RENAL	Serum Osmolarity	> 280 & < 320 mOsm	See Sodium Disorders on page 10 .
	Serum Sodium	> 138 & < 165 meq/L	
INTRACRANIAL PRESSURE MANAGEMENT*			
GENERAL MEASURES	Head in midline position, avoidance of tight cervical collars and tight circumferential ETT ties; elevate the head of the bed to 30 degrees. (Consider reverse Trendelenburg)		
SEDATION	Propofol 1 st choice up to 72°. Other short-acting agents (Fentanyl, Versed) upon discretion of SICU or neurosurgical staff. Typical ICU Propofol sedation dose range: 20-75 mcg/kg/min.		
TEMPERATURE	Aggressive temperature management. Consider cooling measures (Tylenol, cooling blanket) even for <i>modest</i> temperature elevations (>98.6° F).		

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MONITORING & LABS	GENERAL INDICATIONS*		
INTRACRANIAL DYNAMICS	<input type="checkbox"/> Treat sustained ICP elevations >20 <input type="checkbox"/> Always consider an expanding mass lesion with ICP elevations refractory to therapy.		
Treatment Paradigm for the Traumatic Brain Injury Patient*			
TITRATE TO EFFECT Goal of ICP < 20	Ensure sedation and analgesia are adequate	Titrate lowest possible dose to achieve desired RASS score and/or BIS 60-80. Avoid routine over sedation.	
	Initiate CSF drainage via ventriculostomy	Consider ventriculostomy drainage to control ICP to < 20 mm Hg	
	Initiate osmotic therapy Hold if [Na+] is >159 and/or the Sosm is >329	Hypertonic Saline (3%): Bolus therapy is 100-250 ml over 10 min and/or infusion rates range between 25-100 ml/hr. (see Appendix B). As optional or adjunctive therapy consider Mannitol: 0.25–1 gm/kg over < 20 minutes then 0.25 gm/kg q 6 h. 23.4% HTS (Bolus 30 mL IV administered over 10-15 min)may also be considered as an alternative to Mannitol if available ¹¹ .	
	Initiate paralysis	Vecuronium: 10 mg IVP or 0.1 mg/kg. Cisatracurium (if available): Loading dose 0.2 mg/kg/Maintain infusion rates: 1-3 mcg/kg/min	
	Titrate EtCO2	PaCO2 ≥35	
CEREBRAL PERFUSION PRESSURE MANAGEMENT (CPP = MAP – ICP)*			
CPP GOAL >60 mm Hg	1. Ensure euvolemia	Utilize endpoints of resuscitation (exam, vitals, Art. Line, CVP, PAC)	
	Control the ICP First line: 3% saline; Second line: Mannitol or 23.4% HTS. Do Not use Mannitol in hypovolemic patients.		
	2. Consider vasoactive drugs	Consider patient physiology. Vasopressin is agent of choice, followed by Phenlepherine or Norepinephrine.	
ACUTE CLINICAL DETERIORATION (e.g., Acute mental status change, blown pupil or other obvious signs of cerebral herniation, new focal neurological symptoms, progressive and refractory ICP elevation)*			
1. Verify oxygenation and ventilation	UNCAL HERNIATION SYNDROME <input type="checkbox"/> Unilaterally dilating pupil <input type="checkbox"/> Progression to fixed and dilated <input type="checkbox"/> Progressive impairment of consciousness → comatose <input type="checkbox"/> Contralateral Babinski → contralateral weakness → bilateral decerebrate rigidity		
2. Hyperventilate (PaCO2 30-35 mmHg) to temporize only			
3. Re-dose osmotic agent			
4. Call Neurosurgery			
5. Arrange for emergent CT scan			
GLASGOW COMA SCORE	Eye Opening	Best Verbal Effort	Best Motor Effort
1	None	None	Flaccid
2	To Pain	Nonspecific sounds	Decerebrates to pain
3	To verbal stimuli	Inappropriate words	Decorticates to pain
4	Spontaneous	Confused	Withdraws to pain
5	-	Oriented	Localizes to pain
6	-	-	Follows commands

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COMMON SODIUM DISORDERS SEEN IN HEAD TRAUMA (Discuss therapy with staff prior to initiation.)			
Disorder	Na+	Diagnostic clues	Treatment
SIADH	<input type="checkbox"/>	Low Sosm, <u>usually euvolemic</u> , <input type="checkbox"/> Uosm Low serum Uric acid level	Free water restriction, hypertonic saline if severe
Cerebral salt wasting	<input type="checkbox"/>	Sosm may be nl, <input type="checkbox"/> uop, <u>signs of volume depletion & hemoconcentration</u> , very high U _{Na} Normal serum uric acid level	Volume replacement with NS or hypertonic saline. Oral sodium. Beware of rapid Na ⁺ correction.
Mannitol use	<input type="checkbox"/>	Polyuria, <input type="checkbox"/> [Na ⁺] & Sosm	Hold Mannitol if Sosm > 329 mosm / [Na ⁺] > 159
Diabetes Insipidus	<input type="checkbox"/>	Polyuria (>250cc/hr), <input type="checkbox"/> [Na ⁺] & Sosm, U _{spGr} <1.005	DDAVP 2-4 mcg SQ/IV BID as permitted by staff neurosurgeon

** Individualized patient management in consultation with Neurosurgeon*

APPENDIX B 3% Saline Protocol

Hypertonic (3% saline) may be delivered via peripheral IV or intraosseous access

1. Give 250cc 3% NaCl bolus IV (children 5 cc/kg) over 10–15 minutes.
2. Follow bolus with infusion of 3% NaCl at 50 cc/hour.
3. If awaiting transport; check serum Na⁺ levels every hour:
 - a. If Na < 150 mEq/L re-bolus 150 cc over 1 hour then resume previous rate
 - b. If Na 150–154, increase NaCl infusion 10 cc/hr
 - c. If Na 155–160, continue infusion at current rate
 - d. If Na >160, hold infusion, recheck in 1 hour
4. Once Na is within the range- continue to follow the serum Na⁺ level every 6 hours
5. After cessation of 3% NaCl infusion, continue to monitor serum Na for 48 hours to monitor for rebound hyponatremia.

APPENDIX C

ADDITIONAL INFORMATION REGARDING OFF-LABEL USES IN CPGs

1. Purpose.

The purpose of this Appendix is to ensure an understanding of DoD policy and practice regarding inclusion in CPGs of “off-label” uses of U.S. Food and Drug Administration (FDA)–approved products. This applies to off-label uses with patients who are armed forces members.

2. Background.

Unapproved (i.e., “off-label”) uses of FDA-approved products are extremely common in American medicine and are usually not subject to any special regulations. However, under Federal law, in some circumstances, unapproved uses of approved drugs are subject to FDA regulations governing “investigational new drugs.” These circumstances include such uses as part of clinical trials, and in the military context, command required, unapproved uses. Some command requested unapproved uses may also be subject to special regulations.

3. Additional Information Regarding Off-Label Uses in CPGs.

The inclusion in CPGs of off-label uses is not a clinical trial, nor is it a command request or requirement. Further, it does not imply that the Military Health System requires that use by DoD health care practitioners or considers it to be the “standard of care.” Rather, the inclusion in CPGs of off-label uses is to inform the clinical judgment of the responsible health care practitioner by providing information regarding potential risks and benefits of treatment alternatives. The decision is for the clinical judgment of the responsible health care practitioner within the practitioner-patient relationship.

4. Additional Procedures.

- a. Balanced Discussion. Consistent with this purpose, CPG discussions of off-label uses specifically state that they are uses not approved by the FDA. Further, such discussions are balanced in the presentation of appropriate clinical study data, including any such data that suggest caution in the use of the product and specifically including any FDA-issued warnings.
- b. Quality Assurance Monitoring. With respect to such off-label uses, DoD procedure is to maintain a regular system of quality assurance monitoring of outcomes and known potential adverse events. For this reason, the importance of accurate clinical records is underscored.
- c. Information to Patients. Good clinical practice includes the provision of appropriate information to patients. Each CPG discussing an unusual off-label use will address the issue of information to patients. When practicable, consideration will be given to including in an appendix an appropriate information sheet for distribution to patients, whether before or after use of the product. Information to patients should address in plain language: a) that the use is not approved by the FDA; b) the reasons why a DoD health care practitioner would decide to use the product for this purpose; and c) the potential risks associated with such use.