

---

# Contents

<b>Preface</b> .....	xv
<b>Contributors</b> .....	xvi
<b>1. Encephalopathy and Delirium</b> .....	1
<i>Catriona M. Harrop</i>	
<b>1.1 Encephalopathy</b> .....	1
1.1.1 Definition .....	1
1.1.2 Causes of Encephalopathy .....	1
1.1.3 Diagnosis of Encephalopathy .....	1
1.1.4 Treatment of Encephalopathy .....	3
1.1.5 Relationship to Delirium .....	3
<b>1.2 Delirium</b> .....	3
1.2.1 Definition .....	3
1.2.2 Duration of Symptoms .....	4
1.2.3 Level of Activity .....	4
1.2.4 Risk Factors for Delirium .....	5
1.2.5 Clinical Assessment .....	5
<b>1.3 Treatment</b> .....	8
1.3.1 Medications for Agitation .....	8
1.3.2 Pharmacologic Management of Hyperactive Delirium and Agitation .....	8
1.3.3 Nonpharmacologic Treatments for Delirium .....	8
<b>2. Cerebrovascular Emergency: Acute Stroke Diagnosis and Management</b> .....	11
<i>Maria Carissa C. Pineda, Sridhara S. Yaddanapudi, and Norman Ajiboye</i>	
<b>2.1 Epidemiology</b> .....	11
<b>2.2 Etiology</b> .....	11
2.2.1 Nonmodifiable Risk Factors .....	11
2.2.2 Modifiable Risk Factors .....	11
2.2.3 Stroke Subtypes .....	12
<b>2.3 Common Clinical Presentations</b> .....	12
<b>2.4 Differential Diagnosis for Acute Ischemic Stroke</b> .....	12

## Contents

---

<b>2.5</b>	<b>Acute Stroke Diagnosis, Treatment, and Management</b> .....	13
2.5.1	Stroke Activation .....	13
<b>2.6</b>	<b>Criteria for Endovascular Therapy</b> .....	18
2.6.1	Neurocritical Care Management of Ischemic Stroke .....	23
<b>2.7</b>	<b>Stroke Workup and Management</b> .....	26
2.7.1	Post Stroke Complication .....	28
<b>3.</b>	<b>Cerebrovascular Emergency: Spontaneous Intracerebral Hemorrhage (ICH)</b> .....	33
	<i>Syed Omar Shah</i>	
<b>3.1</b>	<b>Epidemiology</b> .....	33
<b>3.2</b>	<b>Etiologies/Differential Diagnosis</b> .....	33
<b>3.3</b>	<b>Common Clinical Presentations</b> .....	34
<b>3.4</b>	<b>Neuroimaging</b> .....	35
<b>3.5</b>	<b>Treatment</b> .....	35
3.5.1	Aggressive Reduction in SBP to Goal of 140 .....	37
3.5.2	Seizures .....	37
3.5.3	Intracranial Pressure .....	37
3.5.4	Medical Issues .....	37
3.5.5	Coagulopathies .....	38
3.5.6	Surgical Options .....	38
3.5.7	Craniotomy .....	38
3.5.8	Craniectomy .....	38
3.5.9	Minimally Invasive Surgical Evacuation .....	40
<b>3.6</b>	<b>Prognosis</b> .....	40
<b>4.</b>	<b>Cerebrovascular Emergencies: Aneurysmal Subarachnoid Hemorrhage (SAH)</b> .....	45
	<i>Norman Ajiboye, Yu Kan Au, and Syed Omar Shah</i>	
<b>4.1</b>	<b>Epidemiology</b> .....	45
<b>4.2</b>	<b>Risk Factors</b> .....	45
<b>4.3</b>	<b>Diagnosis</b> .....	45
<b>4.4</b>	<b>Grading System</b> .....	46
4.4.1	Hunt and Hess Grade .....	46

4.4.2	World Federation of Neurological Surgeons Grade .....	47
4.4.3	Modified Fischer Scores .....	47
<b>4.5</b>	<b>Management of Subarachnoid Hemorrhage .....</b>	<b>47</b>
4.5.1	Early Phase .....	48
4.5.2	Late Phase .....	51
<b>4.6</b>	<b>Vasospasm, Delayed Neurologic Deterioration (DND), and Delayed Cerebral Ischemia (DCI).....</b>	<b>53</b>
4.6.1	Detection and Management of Vasospasm and DCI .....	54
<b>4.7</b>	<b>Hyponatremia and Endocrine Dysfunction .....</b>	<b>56</b>
4.7.1	Hyponatremia .....	56
4.7.2	Endocrine Dysfunction .....	56
<b>5.</b>	<b>Transfusion Medicine and Anticoagulation.....</b>	<b>58</b>
	<i>Bhuvanesh Govind and Matthew Vibbert</i>	
<b>5.1</b>	<b>Introduction .....</b>	<b>58</b>
<b>5.2</b>	<b>Anemia in the ICU.....</b>	<b>58</b>
<b>5.3</b>	<b>Red Cell Transfusion .....</b>	<b>59</b>
5.3.1	Leukocyte Reduction Indications .....	59
5.3.2	Washed RBC.....	59
5.3.3	Irradiation.....	59
5.3.4	Complications of Red Blood Cell Transfusion .....	59
5.3.5	Benefits to Transfusion .....	60
<b>5.4</b>	<b>Hemoglobin “Triggers” .....</b>	<b>60</b>
<b>5.5</b>	<b>Thrombocytopenia .....</b>	<b>61</b>
<b>5.6</b>	<b>Prophylaxis Thresholds .....</b>	<b>62</b>
5.6.1	Treatment of Bleeding.....	62
<b>5.7</b>	<b>Antiplatelet Reversal in Intracranial Hemorrhage.....</b>	<b>62</b>
<b>5.8</b>	<b>Coagulation Cascade and Anticoagulants .....</b>	<b>64</b>
<b>5.9</b>	<b>Anticoagulants.....</b>	<b>64</b>
5.9.1	Warfarin .....	64
<b>5.10</b>	<b>Oral Factor Xa Inhibitors.....</b>	<b>66</b>
5.10.1	Apixaban, Rivaroxaban, Edoxaban.....	66
<b>5.11</b>	<b>Thrombin Inhibitors .....</b>	<b>67</b>

## Contents

---

5.11.1	Oral.....	67
5.11.2	Intravenous.....	69
<b>5.12</b>	<b>The Heparins.....</b>	<b>70</b>
5.12.1	Unfractionated Heparin.....	70
5.12.2	Low-Molecular-Weight Heparin (LMWH).....	70
5.12.3	Fondaparinux.....	71
<b>5.13</b>	<b>Deep Vein Thrombosis (DVT) Prophylaxis.....</b>	<b>72</b>
<b>6.</b>	<b>Cerebral Edema and Elevated Intracranial Pressure.....</b>	<b>75</b>
	<i>Anna Karpenko and Michelle Ghobrial</i>	
<b>6.1</b>	<b>The Basics.....</b>	<b>75</b>
6.1.1	Monro-Kellie Doctrine.....	75
6.1.2	ICP and Cerebral Perfusion Pressure (CPP).....	75
6.1.3	Intracranial Compliance.....	76
6.1.4	ICP Waveforms and Herniation Syndromes.....	76
<b>6.2</b>	<b>Cerebral Edema.....</b>	<b>81</b>
<b>6.3</b>	<b>Stepwise Approach to the Management of Elevated ICP.....</b>	<b>82</b>
<b>6.4</b>	<b>Management of Increased Intracranial Pressure.....</b>	<b>84</b>
6.4.1	Tier 1.....	84
6.4.2	Tier 2.....	84
6.4.3	Tier 3.....	86
<b>7.</b>	<b>Fevers and Infections in the Neuro-ICU.....</b>	<b>91</b>
	<i>Deena M. Athas, Amna Sheikh, and Jacqueline S. Urtecho</i>	
<b>7.1</b>	<b>Brain.....</b>	<b>91</b>
7.1.1	Meningitis.....	91
7.1.2	Acute Bacterial Meningitis.....	92
7.1.3	Aseptic Meningitis.....	96
7.1.4	Viral Meningitis.....	96
7.1.5	Fungal Meningitis.....	97
7.1.6	Ventriculitis.....	97
7.1.7	HIV-Related Infections.....	99
7.1.8	Empyema.....	103
<b>7.2</b>	<b>Spine.....</b>	<b>104</b>
7.2.1	Epidural Abscess.....	104
7.2.2	Osteomyelitis.....	106
<b>7.3</b>	<b>Central Fever.....</b>	<b>108</b>

<b>8.</b>	<b>Treatment of Status Epilepticus in Adults</b> .....	111
	<i>James Park, Alan Wang, Andres Fernandez, and Sara Hefton</i>	
<b>8.1</b>	<b>Overview and Definitions</b> .....	111
<b>8.2</b>	<b>Convulsive Status Epilepticus Management</b> .....	112
<b>8.3</b>	<b>Nonconvulsive Status Epilepticus (NCSE)</b> .....	115
<b>8.4</b>	<b>Refractory Status Epilepticus (RSE)</b> .....	116
<b>8.5</b>	<b>Super Refractory Status Epilepticus (SRSE)</b> .....	116
<b>9.</b>	<b>Trauma</b> .....	119
	<i>Ravichandra Madineni and Christian Hoelscher</i>	
<b>9.1</b>	<b>Acute Spinal Cord Injury</b> .....	119
9.1.1	Introduction .....	119
9.1.2	Medical Treatment of Acute SCI .....	119
9.1.3	Surgical Management of Acute SCI.....	121
<b>9.2</b>	<b>Traumatic Brain Injury</b> .....	122
9.2.1	Introduction .....	122
9.2.2	Management of Elevated ICP.....	125
9.2.3	Other Post-TBI Considerations .....	126
<b>9.3</b>	<b>Paroxysmal Sympathetic Hyperactivity (PSH)</b> .....	127
<b>10.</b>	<b>Neuromuscular and Other Neurologic Emergencies</b> .....	132
	<i>Danielle Wilhour and Alison L. Walsh</i>	
<b>10.1</b>	<b>Guillain-Barré Syndrome (GBS)/Acute Inflammatory Demyelinating Polyradiculoneuropathy (AIDP)</b> .....	132
10.1.1	Definition .....	132
10.1.2	Epidemiology.....	132
10.1.3	Differential Diagnosis.....	133
10.1.4	Common Clinical Presentation .....	133
10.1.5	Diagnosis.....	133
10.1.6	GBS Variants .....	133
10.1.7	Ancillary Testing .....	134
10.1.8	Complications of GBS.....	134
10.1.9	Management .....	135
10.1.10	Prognosis.....	135
<b>10.2</b>	<b>Myasthenia Gravis</b> .....	136
10.2.1	Definition .....	136

## Contents

---

10.2.2	Epidemiology	136
10.2.3	Differential Diagnosis	136
10.2.4	Clinical Presentation of Generalized Myasthenia Gravis	136
10.2.5	Diagnosis	137
10.2.6	Management of Myasthenic Crisis	137
10.2.7	Prognosis	138
<b>10.3</b>	<b>Botulism</b>	<b>139</b>
10.3.1	Definition	139
10.3.2	Epidemiology	139
10.3.3	Pathophysiology	139
10.3.4	Differential Diagnosis	139
10.3.5	Clinical Presentation	139
10.3.6	Diagnosis	140
10.3.7	Management	140
10.3.8	Prognosis	140
<b>10.4</b>	<b>Organophosphate Toxicity</b>	<b>141</b>
10.4.1	Definition	141
10.4.2	Epidemiology	141
10.4.3	Pathophysiology	141
10.4.4	Differential Diagnosis	141
10.4.5	Clinical Presentation	141
10.4.6	Diagnosis	141
10.4.7	Management	142
10.4.8	Prognosis	142
<b>10.5</b>	<b>Neuroleptic Malignant Syndrome (NMS) and Serotonin Syndrome (SS)</b>	<b>142</b>
10.5.1	Definition	142
10.5.2	Epidemiology	143
10.5.3	Pathogenesis	143
10.5.4	Differential Diagnosis	143
10.5.5	Clinical Presentation	143
10.5.6	Diagnosis	143
10.5.7	Management	144
10.5.8	Complications	145
10.5.9	Prognosis	146
<b>11.</b>	<b>Brain Tumor Postoperative Management</b>	<b>149</b>
	<i>Richard F. Schmidt, Nikolaos Mouchtouris, Muaz Qayyum, James J. Evans, and Christopher Farrell</i>	
<b>11.1</b>	<b>Introduction</b>	<b>149</b>
11.1.1	Clinical Presentation	150
11.1.2	Tumor Classification	151

<b>11.2 Postoperative Care and Complications</b> .....	152
11.2.1 Airway Management .....	152
11.2.2 Blood Pressure Control and Postoperative Hemorrhage .....	156
11.2.3 Seizure Prophylaxis .....	156
11.2.4 Venous Thromboembolism Prophylaxis .....	157
11.2.5 Antibiotic Prophylaxis and Postoperative Infection .....	158
11.2.6 Cerebral Edema .....	159
11.2.7 CSF Leak .....	160
<b>11.3 Specific Concerns for Sellar and Parasellar Tumors</b> .....	162
11.3.1 Hormonal Dysregulation .....	162
11.3.2 Pituitary Apoplexy .....	164
<b>11.4 Conclusion</b> .....	165
<b>12. Brain Death in Adults</b> .....	169
<i>Rodney D. Bell, Norman Ajiboye, and Yu Kan Au</i>	
<b>12.1 Definition of Brain Death</b> .....	169
<b>12.2 Clinical Evaluation</b> .....	169
12.2.1 Establishing the Proximate Cause of Coma .....	170
12.2.2 Clinical Examination to Establish Irreversibility .....	170
<b>12.3 Ancillary Tests</b> .....	171
<b>12.4 Legal</b> .....	171
<b>12.5 Management of the Brain-Dead Patient for Organ Donation</b> .....	172
<b>13. Sodium Dysregulation</b> .....	178
<i>M. Kamran Athar and Christian Bachelier</i>	
<b>13.1 Terminology</b> .....	178
<b>13.2 Hyponatremia Classification</b> .....	178
13.2.1 Causes of Hyponatremia .....	179
13.2.2 Symptomatic Hyponatremia .....	179
<b>13.3 SIADH versus CSW</b> .....	181
13.3.1 Syndrome of Inappropriate Antidiuretic Hormone Secretion (SIADH) .....	181
13.3.2 Cerebral Salt Wasting (CSW) .....	181
13.3.3 SIADH and CSW Diagnosis .....	182
<b>13.4 Diagnostic Approach to Hyponatremia</b> .....	183
13.4.1 Hyponatremia Treatment: General Principles .....	184

## Contents

---

13.4.2	Acute Symptomatic Moderate to Severe Hyponatremia .....	184
13.4.3	Acute Asymptomatic Moderate Hyponatremia .....	185
13.4.4	Severe Chronic Mild-Moderate Hyponatremia .....	185
13.4.5	SIADH Treatment .....	186
13.4.6	CSW Treatment .....	186
13.4.7	Treatment of Hyponatremia in Patients with Subarachnoid Hemorrhage .....	186
13.4.8	Treatment of Hyponatremia in Patients with Heart Failure .....	187
<b>13.5</b>	<b>Hyponatremia</b> .....	<b>187</b>
13.5.1	Central (Neurogenic) Diabetes Insipidus .....	187
13.5.2	Nephrogenic Diabetes Insipidus .....	189
<b>13.6</b>	<b>Diagnostic Approach to Hyponatremia</b> .....	<b>189</b>
13.6.1	Treatment .....	190
13.6.2	Central DI Treatment .....	192
13.6.3	Nephrogenic DI Treatment .....	192
<b>14.</b>	<b>Nutrition</b> .....	<b>194</b>
	<i>Stephanie Dobak and Jacqueline S. Urtecho</i>	
<b>14.1</b>	<b>Glucose Utilization</b> .....	<b>194</b>
<b>14.2</b>	<b>Nutrition in Critical Care</b> .....	<b>194</b>
<b>14.3</b>	<b>Nutrition Status</b> .....	<b>196</b>
14.3.1	Malnutrition .....	196
14.3.2	Refeeding Syndrome .....	198
14.3.3	Nutrition-Related Laboratory Tests .....	198
<b>14.4</b>	<b>Nutrition Assessment</b> .....	<b>198</b>
14.4.1	Calorie Needs .....	198
14.4.2	Protein Needs .....	199
14.4.3	Nutrition Support .....	200
14.4.4	Enteral Nutrition .....	200
<b>14.5</b>	<b>Specific EN Considerations</b> .....	<b>204</b>
14.5.1	Parenteral Nutrition .....	204
<b>14.6</b>	<b>Therapy-Specific Considerations</b> .....	<b>204</b>
<b>14.7</b>	<b>Conclusion</b> .....	<b>208</b>
<b>15.</b>	<b>Sedation</b> .....	<b>210</b>
	<i>Akta Patel and Michelle Ghobrial</i>	
<b>15.1</b>	<b>Introduction</b> .....	<b>210</b>

<b>15.2</b>	<b>Indications for Sedation</b> .....	210
<b>15.3</b>	<b>Complications of Sedation</b> .....	211
<b>15.4</b>	<b>Assessment of Sedation</b> .....	211
<b>15.5</b>	<b>Choice of Sedative</b> .....	212
15.5.1	Propofol (Diprivan) .....	216
15.5.2	Midazolam (Versed) .....	217
15.5.3	Dexmedetomidine (Precedex) .....	218
15.5.4	Fentanyl (Sublimaze) .....	219
15.5.5	Ketamine (Ketalar) .....	220
<b>16.</b>	<b>Pain Management in the Neuro-Intensive Care Unit (ICU)</b> .....	222
	<i>Amy Shah, David A. Wyler, and Andrew Ng</i>	
<b>16.1</b>	<b>Introduction</b> .....	222
<b>16.2</b>	<b>Modern Strategy of Pain Management in ICU Liberation</b> .....	223
<b>16.3</b>	<b>Challenges of Pain Management in Neuro-ICU</b> .....	224
<b>16.4</b>	<b>Individualizing Therapy in NICU</b> .....	224
16.4.1	Pharmacologic Interventions of Pain .....	224
16.4.2	Nonpharmacologic Approach .....	233
<b>16.5</b>	<b>Neuro-specific Diseases at Risk for Pain</b> .....	233
16.5.1	Pain with SAH .....	233
16.5.2	Spondylosis and Disk Herniation .....	233
16.5.3	Spasticity .....	234
<b>16.6</b>	<b>Ongoing Continuous Pain Monitoring in NICU</b> .....	234
16.6.1	Pain Scales .....	234
<b>17.</b>	<b>Advanced Hemodynamic and Neurological Monitoring in the Neuro-ICU</b> .....	238
	<i>David F. Slottje and John W. Liang</i>	
<b>17.1</b>	<b>Hemodynamic Monitoring</b> .....	238
17.1.1	Invasive Monitoring: Pulmonary Thermodilution .....	240
17.1.2	Less Invasive: Transpulmonary Thermodilution .....	241
17.1.3	Minimally Invasive Monitoring: Pulse Contour Analysis .....	245
17.1.4	Noninvasive Hemodynamic Monitoring .....	247
<b>17.2</b>	<b>Neurological Monitoring</b> .....	249
17.2.1	Noninvasive Monitors .....	249

## Contents

---

17.2.2	Invasive Monitors: Cerebral Oximetry .....	254
17.2.3	Cerebral Blood Flow Monitors.....	260
17.2.4	Intracranial Pressure Monitoring .....	261
<b>18.</b>	<b>Neuroimaging</b> .....	<b>266</b>
	<i>Michael J. Lang</i>	
<b>18.1</b>	<b>Introduction</b> .....	<b>266</b>
<b>18.2</b>	<b>Types of Imaging</b> .....	<b>266</b>
18.2.1	Brain Imaging.....	266
18.2.2	Spine Imaging .....	266
<b>18.3</b>	<b>Advantages and Limitations</b> .....	<b>267</b>
18.3.1	Brain Imaging.....	267
18.3.2	Spine Imaging .....	279
18.3.3	Systemic.....	281
<b>19.</b>	<b>Ventilation Strategies in Neuro-ICU</b> .....	<b>285</b>
	<i>Amandeep S. Dolla and M. Kamran Athar</i>	
<b>19.1</b>	<b>Introduction</b> .....	<b>285</b>
<b>19.2</b>	<b>Respiratory Failure</b> .....	<b>285</b>
19.2.1	Noninvasive Oxygenation and Ventilation.....	285
19.2.2	Invasive Mechanical Ventilation .....	289
19.2.3	Basic Principles of Mechanical Ventilation .....	291
19.2.4	Modes of Ventilation .....	292
19.2.5	Initial Ventilator Settings .....	294
19.2.6	For Pressure Ventilation .....	295
19.2.7	Common Ventilator Problems.....	295
19.2.8	Weaning from Ventilator .....	295
19.2.9	WHEANS NOT Mnemonic.....	295
19.2.10	Extubation Procedure .....	297
	<b>Index</b> .....	<b>299</b>