Interest in decompressive craniectomy (DC) to manage neurological emergencies including stroke has waxed and waned for decades. The best evidence for the use of DC is in patients with refractory cerebral edema related to large territory ischemic stroke. Although many publications have evaluated the role of craniectomy in managing neurological emergencies, none outline care priorities for patients who have received the procedure.

Background and Significance
Although the use of DC to manage stroke, intracerebral hemorrhage (ICH), or subarachnoid hemorrhage (SAH) represents a minority of patients, those undergoing craniectomy are the most acutely ill and vulnerable patient population. In review of the American Heart Association/American Stroke Association clinical practice guidelines for management of stroke, DC is mentioned as a life-saving procedure. However, little is mentioned about the organization of care of the patient who has undergone DC.

Methods
We conducted a narrative, comprehensive review of the literature aimed at to define the specific care needs of a patient with stroke who receives craniectomy. Search terms included craniectomy in multiple variations, ischemic stroke, ICH, SAH, complications, and nursing care. More than 60 publications were reviewed. No trials of reviews that addressed the unique or specific care needs of patient were found. When the initial search of the literature revealed a dearth of information beyond indications for the use of DC and complications, the team altered course to understand the care priorities based on complications associated with the procedure. From the review, a summary of nursing care priorities was generated. In addition, priorities for future research were identified.

Complications Associated With DC
DC associates with several unique complications. Although the frequency of any 1 complication may be low, case series indicate that the over frequency of complications may be high for patient after DC.1 However, the quantification of complications is difficult as many patients are recovering from their procedure. More evidence is needed to best understand which patients are most susceptible to complications.

The complications associated with DC are best described according to the timeframe they generally appear. Short-term postoperative complications include herniation through bone window, surgical site infection, contralateral hematoma, particularly when DC is performed in the setting of elevated intracranial pressure such as in patients with neurotrauma and ICH, ipsilateral subdural or subgiall effusion, early seizure, and cerebrospinal fluid leakage. Patients may continue to experience elevated intracranial pressure related to small bone window size or continued cerebral edema unrelieved by craniectomy. Within the first several weeks of care to 3 months after procedure, persistent hydrocephalus seems as a unique complication of DC. Although some patients with ischemic stroke, ICH, and SAH may experience hydrocephalus requiring shunt placement as a natural course of the disease, DC seems to increase the likelihood that patients will not be able to wean from the external drain and require the placement of a shunt.2,3

Patients with DC are at high risk for fall from their underlying stroke pathology and are at higher risk for injury after fall because of the compromised skull bone. Single case reports indicate that fall after DC may have disastrous consequences. Although an in-hospital fall may result in an adverse outcome including trauma and even death in any patient population, patients after DC are at a higher risk for adverse outcome after fall because of the compromised skull bone and exposed cerebrum. Centers with adverse events related to fall after craniectomy recommended including cognitive assessment in the postcraniectomy care and considering all patients after DC at high risk for fall and injury after fall regardless of neurological examination.4,4a

Sinking skin flap syndrome, or syndrome of trephined, seems as a DC-related complication in the first several weeks and months after DC. The syndrome describes a cluster of symptoms including depressed mood, headache, behavioral disturbance, and seizure related to cerebral cortex distortion under the skin flap once cerebral edema subsides.5 The development of symptoms is often insidious, but may be acute, and may be exacerbated by dehydration and patient positioning. The syndrome may be associated with acute neurological change and paradoxical herniation.6 The exact pathological mechanism is unclear but may be related to atmospheric pressure on the cortex. The frequency of this complication is difficult to determine, many patients are recovering from their...
illness, may have a poor baseline examination or difficulty communicating the symptoms. It is difficult to discern this syndrome from complications associated with the underlying neurological injury. The syndrome is described most frequently in the trauma literature and is reported in DC after stroke, particularly large-sized DC. More studies are needed to define which patients are at highest risk and the true occurrence of this complication in DC after stroke, aneurysmal subarachnoid hemorrhage, and ICH. There is some indication that replacement of the bone flap is associated with improvement in symptoms, although more research is needed to help guide the timing of bone flap replacement in these patients.

In the long term after DC, complications related to the procedure persist. They include the continued development of ipsilateral effusion, late-onset seizure, and epilepsy and continued complications related to syndrome of trephined. Recent reports suggest that late-onset seizures and refractory seizures may be common and under-recognized. In addition, retrospective reviews indicate that patients with DC may be at high risk for developing poststroke depression.

The ideal storage of the bone flap and timing of replacement continue to be a matter of debate. The replacement of the autologous or synthetic bone flap is also associated with some risk of complication. Complications noted in the literature related to cranioplasty include infection, hematoma, hydroma, and bone flap resorption. Acute cerebral edema and death after craniectomy are also reported. Although these complications are rare, they can be serious and should be taken into consideration when counseling families on the procedure and planning care after procedure. It is also possible that because of the lack of adequate monitoring, the complications associated with cranioplasty are underreported.

Nursing Priorities for Patients With DC

Given the lack of publications on the care of patients undergoing craniectomy, the evidence reviewed on indications for craniectomy and complications associated with the procedure were used to identify nursing and interprofessional team care priorities as well as organize priorities for further research. Although the medical community continues to organize clinical trials to evaluate the role of DC in stroke care, and even call into question the widespread use of the procedure outside of guidelines and evidence, patients across the nation continue to receive this procedure. A nursing care protocol was developed to guide nursing care in the weeks after the procedure (Figure). Additional research is needed to continue to identify how to best care for these patients as they recover.

Short-Term Care Priorities

In the first few weeks after procedure, care focuses on the recovery from ischemic stroke, ICH, and SAH while preventing complications related to the DC. Of paramount importance is protecting the exposed cranium from fall or pressure with proper positioning, head protection, and helmet. A significant concern for a patient after DC is pressure to the open cerebrum or injury from fall. Positioning the patient onto the craniectomy site may place pressure on the cerebrum and should be avoided. Positioning may be supported with towels, pillows, and positioning devices to prevent pressure onto the cerebrum. Although the frequency of neurological worsening related to fall after DC is not well measured in the literature, several case reports highlight the danger.

The routine use of a helmet for any mobilization after craniectomy is common practice, reported as part of routine care in several case reports and case series. However, the role of helmets in preventing postcraniectomy injury has never been studied in any organized fashion. Further trials are needed to better quantify the benefit of a helmet after DC and the appropriate minimum criteria for fitting the helmet after DC. When used, the helmet should be fit to the patient by an orthotics specialist to minimize pressure on the open cerebrum as well as skin over the skull.4

Nursing assessment of patients in the days and first weeks after DC should be frequent and thorough, and focused on the potential to develop neurological deterioration from continued elevated intracranial pressure, clinically evident or subclinical seizure, effusion or hematoma, or hydrocephalus. The DC surgical site should be monitored for turgor and pressure at the

Figure. Nursing priorities for the care of patients with decompressive craniectomy. ICP indicates intracranial pressure.
site, as well as any early signs of wound infection. The placement of a pressure dressing in the immediate postoperative period is associated with decreased rate of subdural effusion in the traumatic brain injury population. However, this finding needs to be studied in the patient population with stroke.

Intermediate Care Priorities
In the weeks and first several months after DC, the patient should be closely observed for any personality changes and decreased level of consciousness that may indicate syndrome of trephinied or complications from hydrocephalus. This is a particularly vulnerable time for patients with stroke, as they have often transferred out of the hospital to a subacute placement or home with family. A rapid or insidious change in personality or neurological examination may indicate the development of late-onset seizures, hydrocephalus, or syndrome of trephinied.

Long-Term Care Priorities
In the months after DC, care should be coordinated between teams to identify the ideal timing of flap replacement and monitoring for cranioplasty-related complications. These complications include infection from the cranioplasty procedure and bone flap resorption. Although resorption is more common in patients with neurotrauma, patients with stroke may experience this complication and should be monitored. Patients are at risk for late-onset seizure, which may be refractory to routine treatment. Patients are also at high risk for developing depression and should be assessed using evidence-based tools for the presence of depression. No studies have been published evaluating posthospital monitoring of patients after DC. Given the risk for complications and controversies on ideal timing of bone flap replacement, frequent follow-up with the medical and surgical team is warranted. However, it is unclear what posthospital follow-up these patients are receiving.

Implications for Future Research and Quality Monitoring
Although the medical field continues to study and debate the role of craniectomy in the management of neurological emergencies, the unique care priorities for this patient population must be addressed. Additional research is needed to better quantify the care priorities, appropriate interventions, and impact on outcome. An organized approach to care across settings is necessary for patients who have undergone DC, as they are susceptible to complications in the weeks and months after surgery. Alternate research methodologies such as clinical effectiveness research in addition to randomized controlled trials may be useful.

Quality monitoring programs within stroke programs that routinely perform DC should include monitoring for the common short- and long-term complications associated with the procedure. Current databases for monitoring process and outcome in stroke do not collect DC-related measures. Possible metrics include return to the operating room for reoperation for effusion, cerebral spinal fluid leak, or new hematoma; surgical site infection at any stage; and any adverse events related to care of the patient after DC. Programs should have a process to monitor for and intervene with new symptoms that may indicate late-onset seizure, depression, or sinking skin flap syndrome. The program should monitor complications related to cranioplasty. A database was proposed in the United Kingdom aimed at tracking the cranioplasty-related procedure and complication data. A robust database to track the patient experience throughout the DC continuum of care would allow better measurement of current practice and outcomes.

**TAKE-HOME POINTS**

- No studies to date have attempted to quantify the impact of nursing care on pre or post-DC patient outcomes.
- Nursing care should aim to recognize and mitigate common complications associated with DC.
- The patient care team must coordinate services as potential complications and patient care post-DC span multiple weeks and care settings.

**Disclosures**
None.

**References**

toma evacuation for large hemispheric hypertensive intracerebral hemor-

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