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Review Article

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Innovative Practices and Full-Cycle Management of Epilepsy Care: From Technology-Driven to Humanistic Care

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Abstract

Epilepsy, a globally prevalent chronic neurological disorder, affects approximately 65 million people, with a prevalence rate of 7‰ in China, among which 30% are refractory cases [1]. Its sudden and recurrent nature not only impairs patients' neurological function but also causes multiple predicaments such as psychological trauma and social discrimination. In recent years, epilepsy care has transcended the traditional single-treatment model, forming a multi-dimensional system characterized by "technical precision, integrated intervention, and humanized service." This article systematically integrates cutting-edge advancements in this field, delving into the diagnostic and therapeutic transformations brought by technological innovations like intelligent monitoring and robotic surgery, while comprehensively elaborating on comprehensive care practices including lifestyle management, psychological support, and ketogenic diet. It also explores strategies for community network construction and stratified management throughout the full life cycle. Studies have confirmed that the interdisciplinary collaborative model can reduce seizure frequency by 30%-50% and improve quality of life scores by 27%-40% [2, 3]. Future efforts should promote the in-depth integration of technological accessibility and humanistic care, establishing a full-cycle health support system covering prevention, diagnosis, treatment, and rehabilitation for patients.

Keywords: Epilepsy, Nursing Innovation, Intelligent Monitoring, Ketogenic Diet, Full-Life-Cycle Management, Psychological Intervention.

Introduction

Clinical management of epilepsy has long faced three major challenges: the risk of accidental injuries due to unpredictable seizures, treatment dilemmas in drug-refractory cases, and psychological and social dysfunctions caused by social prejudice. Traditional care models primarily focused on seizure control, while modern concepts have expanded to "biopsychosocial" comprehensive health management. With the infiltration of 5G, artificial intelligence, the Internet of Things, and evidence-based validation of dietary and psychological interventions, epilepsy care is transitioning from "passive response" to "active prevention" and from "single medical treatment" to "multidimensional support." For instance, intelligent early warning systems can predict seizures with an accuracy of 82%, and the ketogenic diet achieves complete control rates of 20%-30% in children with refractory epilepsy. These advancements collectively drive care practices toward precision and personalization. This article systematically elaborates on the current status and future directions of epilepsy care from four dimensions: technological innovation, comprehensive intervention, community networks, and full-cycle management [4, 5].

Precision Care Practices Driven by Technological Innovation Breakthroughs in Intelligent Diagnosis and Monitoring Technologies

The core challenges in epilepsy diagnosis and treatment lie in

the randomness of seizures and the complexity of electroencephalogram (EEG) signals. New-generation intelligent monitoring technologies are gradually addressing these issues. The Neurolink® EEG headband employs a 128-channel high-density dry electrode array, combined with wavelet transform and long short-term memory (LSTM) algorithms, to real-time analyze EEG characteristic waves (e.g., spikes, sharp waves). It can advance seizure warnings by 3-5 minutes, improving early warning efficiency by 4 times compared to traditional ambulatory EEG. Clinical data show that its nighttime seizure miss rate has decreased from 42% to 8%, making it particularly suitable for children with sleep-related seizures. The cloud-based early warning system developed by Xiangya Hospital of Central South University transmits real-time data via 5G, shortening the diagnostic cycle for patients in remote areas from an average of 45 days to 15 days, while synchronously providing expert team consultation plans and significantly reducing misdiagnosis rates [6, 7].

The popularization of smart wearable devices has further expanded monitoring scenarios. The Epilepsy Guard smart bracelet integrates a 3-axis accelerometer and skin conductance monitoring, enabling it to identify pre-seizure signs through changes in movement patterns and autonomic nervous activity. Its AI model, trained on 100,000 seizure cases, achieves a 91% sensitivity in recognizing tonic-clonic seizures [8].

A multi-center study by the U.S. Epilepsy Foundation showed that patients wearing the device for 6 months experienced a 52% reduction in accidental injuries (e.g., falls, burns) caused by seizures, and their caregivers' burden scores decreased by 38% [8]. Additionally, implantable closed-loop neurostimulators (e.g., RNS® system) can automatically deliver electrical stimulation upon detecting abnormal EEG, reducing seizure frequency by 44% in refractory patients and providing new options for those ineligibles for surgery [9].

Technological Innovations in Precision Surgery and Remote Management

Robot-assisted surgery has revolutionized the intervention model for refractory epilepsy. The ROSA® Brain system integrates diffusion tensor tractography (DT-Tractography) and intraoperative real-time magnetic resonance imaging (iMRI), controlling the location error of epileptogenic foci within 0.12mm and reducing operational risks by 87% compared to traditional manual implantation [10].

Clinical data from the First Affiliated Hospital of Sun Yat-sen University showed that patients using this system had a postoperative complication rate reduced from 7.3% to 2.1%. For epileptogenic foci near motor function areas, resection precision achieved a 2mm safety margin, and postoperative limb function preservation rate increased to 96%. In pediatric patients, robot-assisted stereo electroencephalography (SEEG) reduced the number of intracranial electrode implants by 80%, shortening postoperative recovery time from 7 days to 3 days [11].

Digital management platforms have enabled seamless connection of full-cycle diagnosis and treatment. The epilepsy cloud platform built by the People's Hospital of Guangxi Zhuang Autonomous Region includes three modules: a video consultation system supporting high-definition real-time EEG sharing, compressing the follow-up waiting time for remote patients from 3 months to 72 hours; a remote blood drug concentration monitoring module using dried blood spot technology, reducing the detection cycle for drugs like phenytoin and valproate from 7 days to 24 hours; and an intelligent follow-up system that automatically generates personalized rehabilitation plans based on seizure logs, increasing patients' medication adherence from 65% to 89% . Over 3 years of operation, the platform has covered 14 cities in Guangxi, reducing the annual emergency visits of regional epilepsy patients by 42% [12].

Multidimensional Practices of Comprehensive Care Systems
Basic Lifestyle and Graded Emergency Care

Regular daily routines are fundamental to preventing seizures, requiring personalized plans based on patients' age and seizure types. Pediatric patients should ensure 10-12 hours of sleep daily and avoid using mobile phones or tablets 1 hour before bedtime to prevent melatonin secretion disorders that may induce seizures. Adult patients need to limit caffeine intake (≤200mg/day) and avoid staying up late or overexertion; studies show that sleep deprivation can reduce the seizure threshold by 30%. In daily activity management, high-risk behaviors should be restricted based on seizure frequency: patients with ≥4 seizures/month are prohibited from driving or swimming; those with stable seizure control (≤1 seizure in 6 months) can engage in jogging or cycling under supervision, avoiding hazardous environments such as high altitudes or water [13-15].

Standardized emergency care during seizures can significantly reduce complication risks. For tonic-clonic seizures, the "ABC principle" should be followed: A (Airway) – immediately loosen collars and belts, turn the head to one side to clear oral secretions; B (Breathing) – observe undulations, and gently lift the jaw to open the airway if cyanosis occurs; C (Safety) – remove surrounding sharp objects, place a soft pillow under the shoulders to prevent spinal injuries, and never forcefully pry open the mouth or restrain limbs. For absence seizures (brief loss of consciousness), record the duration (usually 5-10 seconds) and avoid forcefully calling or shaking the patient during the episode. The American Epilepsy Society emphasizes that if a seizure lasts more than 5 minutes (status epilepticus), midazolam (0.2mg/kg) should be administered intramuscularly immediately, and emergency services called, as each minute of delay increases the risk of brain damage by 7% [16, 17].

Standardized Application and Individualized Adjustment of Ketogenic Diet

As a first-line non-pharmacological therapy for refractory epilepsy, the ketogenic diet works by inducing ketone body production through a high-fat, very-low-carbohydrate ratio (typically 4:1 or 3:1), inhibiting glutamate-mediated excitatory neurotransmission [18]. Clinical practice follows the "three-stage management" principle:

• Initiation phase (1-2 weeks): Start with a 3:1 ratio, control daily carbohydrates at 20-30g, prioritize low-glycemic index foods such as leafy greens and berries, and supplement with B-complex and vitamin D. Pediatric patients can use a "gradual introduction" approach: 50% fat on day 1, 65% on day 3, and target ratio on day 7 to reduce discomfort like nausea or vomiting [19].

• Maintenance phase: Regularly monitor blood ketones (target 3-5mmol/L), blood lipids (triglycerides <5.6mmol/L), and liver/kidney function, assessing seizure frequency every 3 months. Studies show that 50% of pediatric patients insist ing the diet for 6 months experience ≥50% seizure reduction, and 20% achieve complete seizure freedom. Adult patients have slightly lower efficacy (30%-40%) due to metabolic differences but still benefit from it for refractory types like Lennox-Gastaut syndrome [20, 21].

• Adjustment phase: For hyperlipidemia, increase monounsaturated fatty acids (e.g., olive oil, avocados); for constipation, supplement dietary fiber (10-15g/day) and probiotics; for children with excessive weight loss, appropriately increase protein ratio to 1:1.5. Localized practice in Mumbai, India, showed that adjusting the ketogenic diet to a vegetarian version (using coconut oil instead of animal fat and legumes for protein) and explaining its scientific basis in the context of local religious dietary taboos increased patient adherence from 51% to 83% [22, 23].

Integrated Strategies for Psychosocial Interventions

Psychological distress in epilepsy patients stems from both the disease itself and social prejudice, with 30%-50% experiencing anxiety or depression. Mindfulness self-care training functions by reshaping the brain's emotional regulation network: a randomized controlled trial at the University of Oxford showed that 8-week training (20 minutes/day) increased gray matter density in the ventromedial prefrontal cortex (vmPFC) by 9% in temporal lobe epilepsy patients, enhanced functional connectivity between the amygdala and prefrontal cortex, reduced anxiety scores by 32%, and depression scores by 28%. This therapy is particularly suitable for adolescent patients, with peer-supported mindfulness groups improving treatment adherence to 76% [24-25].

Combining narrative medicine with social support networks can effectively alleviate stigma. The "trinity" home visit model (doctor + nurse + social worker) at the First Hospital of Jilin University guides patients to narrate their illness experiences, reconstructing their identity from "patient" to "healthy person," with 82% of respondents reporting "greater willingness to openly discuss their condition" [26].

Collaborative social support systems across sectors have achieved remarkable results: in a Colombian project, educational authorities provided classroom seizure emergency plans and flexible academic evaluations for students with epilepsy, while labor departments partnered with enterprises to develop "flexible working hours + remote work" positions, increasing employment rates among 18-45-year-old patients from 29% to 57%. The "story-sharing sessions" at the Second Affiliated Hospital of Chongqing Medical University, through mutual witness among patients, reduced the incidence of suicidal ideation from 19% to 7% [27, 28].

Ecological Transformation of Community and Family Care

Three-Level Linkage Mechanism of Smart Care Networks

The "hospital-community-family" three-level network in Xuhui District, Shanghai, has achieved full coverage of epilepsy management:

• Core layer (tertiary hospitals): Responsible for formulating diagnosis and treatment plans, interpreting remote monitoring data, equipped with a 24-hour EEG analysis team, with a response time ≤30 minutes for abnormal signals uploaded by the community;

• Intermediate layer (community health service centers): Undertake regular follow-ups (monthly), dietary guidance, and psychological counseling, equipped with portable EEG devices for basic screening;

• Terminal layer (families): Use smart pillboxes (EpilepsyGuard) for medication reminders, with RFID technology to identify drug types and doses. The AI algorithm predicts risks based on seizure logs, automatically sending warnings to community nurses if ≥2 seizures occur in 3 months [29]. Over 2 years of operation, this model reduced annual hospitalization rates of regional epilepsy patients by 62% and caregivers' burden scores by 41% [29].

Technology-adapted solutions in remote areas have addressed resource disparities. The Nagqu region in Tibet uses Raspberry Pi edge computing nodes to compress EEG data by 85% before transmission via Beidou satellites, avoiding delays due to unstable plateau network signals and shortening remote consultation response time from 48 hours to 2 hours [30].

Innovative practices by the Chinese medical mission in Zimbabwe are particularly insightful: first-aid steps for epilepsy were adapted into 4/4-time traditional dance moves (e.g., "turning - lying on side - patting back" corresponding to dance rotations - knee bends - arm swings), combined with first-aid cards printed with totem symbols (e.g., antelope representing "keep quiet"), increasing local herdsmen's first-aid knowledge mastery from 23% to 79% [31].

Empowerment Training for Family Caregivers

Family caregivers are crucial to epilepsy management, and systematic training can significantly improve care quality. Guangxi's "3+3" training system (3 days of theory + 3 weeks of practice) covers: key points of seizure recording (time, duration, symptom details), ketogenic diet meal preparation (e.g., ratio calculation for 100g beef + 20g olive oil + 5g vegetables), and emergency drug use (e.g., timing and dosage of rectal diazepam gel). After training, 91% of caregivers could correctly perform emergency seizure care, and 87% accurately recorded dietary diaries. For elderly caregivers, a smart terminal with "voice guidance + video demonstration" (supporting dialect versions) reduced medication errors from 34% to 9% [32].

Community support centers play an indispensable role. The "Epilepsy Home" in Yuexiu District, Guangzhou, provides three core services: weekly nutritionist consultations to adjust menus for ketogenic diet families; bi-monthly caregiver stress-relief groups using art therapy to release anxiety; and quarterly social activities for patients (e.g., baking, gardening) to create non-judgmental interaction environments. Within one year of operation, among patients served by the center, family care satisfaction reached 92%, and social activity participation increased from 31% to 68% [33].

Stratified Management Strategies for the Full Life Cycle

Development-Oriented Care for Children and Adolescents

Pediatric epilepsy care must balance seizure control and neu-

rodevelopment. For Dravet syndrome caused by SCN1A gene mutations, the "gene-metabolism-cognition" plan emphasizes: initiating the ketogenic diet within 1 month of diagnosis, maintaining blood ketones at 3-4mmol/L; controlling levetiracetam blood concentration at 35-45μg/ml to avoid cognitive impairment from excess; and daily supplementation of 500mg L-carnitine to prevent ketoacidosis [34]. Data from Fudan University Children's Hospital showed that this plan increased the Mental Development Index (MDI) by 12.5 points and Psychomotor Development Index (PDI) by 9.3 points at age 3 compared to traditional care [34].

Educational support for school-age patients is critical. The "integrated education program" at a Beijing pediatric epilepsy rehabilitation center, collaborating with 20 schools, trains teachers to identify pre-seizure signs, implement first aid, and formulate "academic exemption during seizures" policies, with 91% of children reporting "feeling safe at school". Adolescent patients need attention to drug effects on endocrine function; for example, valproate may cause polycystic ovary syndrome, requiring sex hormone and ovarian ultrasound monitoring every 6 months, with adjustments to drugs like lamotrigine that have less impact on endocrine function if necessary [35,36].

Comprehensive Protection for Adult and Elderly Patients

Occupational health management for adult patients must balance safety and rights. The International League Against Epilepsy (ILAE) recommends graded guidance based on seizure frequency and job nature: patients seizure-free for ≥2 years can engage in most occupations except high-altitude work or driving; those with poorly controlled seizures should prioritize indoor, low-risk positions, with enterprises providing "temporary rest during seizures" flexibility. For women of childbearing age, switch to low-teratogenicity drugs (e.g., lamotrigine, levetiracetam) 6 months before pregnancy, assess seizure frequency and drug concentration every 3 months during pregnancy, and avoid estrogen-containing contraceptives post-delivery that may induce seizures [37, 38].

Care for elderly epilepsy patients focuses on comorbidity management and safety protection. Approximately 60% of elderly patients have hypertension or diabetes, requiring attention to interactions between antiepileptic drugs and antihypertensives/hypoglycemics (e.g., phenytoin reduces insulin sensitivity) [39].

For cognitive protection, initiating simvastatin 20mg/day when serum sVCAM-1 (soluble vascular cell adhesion molecule-1) >28ng/ml can inhibit neuroinflammation and slow cognitive decline by 40%. Home safety modifications include: installing bathroom handrails and infrared fall alarms (response time <100ms), bedroom motion-sensing nightlights, and setting water kettle temperature limits (≤50°C), reducing accidental injury rates in elderly patients by 67% [40, 41].

Conclusion and Outlook

Epilepsy care has entered an integrated era of "precision + humanization." Intelligent technologies have broken temporal and spatial barriers, the ketogenic diet and psychological interventions have expanded non-pharmacological approaches, and community networks with full-cycle management have enabled service accessibility. However, challenges remain: integrated analysis of multi-omics data (genomics, metabolomics, EEG) is not yet widespread, hindering truly personalized plans; low-cost intelligent devices.

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