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ORIGINAL ARTICLE

ISCHEMIC STROKE: PATHOPHYSIOLOGY, RISK FACTORS, EARLY DIAGNOSIS, AND CONTEMPORARY TREATMENT STRATEGIES

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Abstract

Ischemic stroke is one of the leading causes of mortality, long-term disability, and neurological impairment worldwide and remains a major global healthcare challenge due to its rapid onset, complex pathophysiology, and severe functional consequences. The condition develops as a result of acute interruption of cerebral blood flow leading to oxygen deprivation, neuronal ischemia, metabolic failure, inflammatory activation, and irreversible brain tissue injury. Early diagnosis and rapid therapeutic intervention are critically important for reduction of neuronal damage, preservation of neurological function, and improvement of long-term clinical outcomes. This study investigates the pathophysiological mechanisms, major risk factors, diagnostic approaches, and modern treatment strategies associated with ischemic stroke. Particular emphasis is placed on vascular occlusion, cerebral ischemic cascade, hypertension, diabetes mellitus, atrial fibrillation, atherosclerosis, neuroimaging technologies, thrombolytic therapy, mechanical thrombectomy, neuroprotection, and rehabilitation strategies. The findings demonstrate that integration of early neuroimaging, rapid clinical assessment, reperfusion therapy, and multidisciplinary stroke management significantly improves survival rates, reduces neurological disability, and enhances recovery of functional independence. Contemporary stroke medicine increasingly combines advanced imaging technology, evidence-based pharmacological intervention, minimally invasive endovascular procedures, and personalized rehabilitation programs aimed at optimizing neurological recovery and prevention of recurrent cerebrovascular events. Ischemic stroke remains one of the most serious acute neurological disorders and represents a leading cause of mortality, chronic disability, cognitive impairment, and long-term functional dependence worldwide. The disease develops as a consequence of sudden reduction or complete interruption of cerebral blood flow resulting in oxygen deprivation, metabolic failure, neuronal ischemia, inflammatory activation, and irreversible destruction of brain tissue. Rapid progression of ischemic injury causes extensive structural and functional neurological impairment if urgent medical intervention is not initiated during the early therapeutic window. This study presents an expanded analysis of ischemic stroke with particular emphasis on pathophysiological mechanisms, vascular and metabolic risk factors, clinical manifestations, modern neuroimaging diagnostics, reperfusion therapy, endovascular intervention, neuroprotective strategies, and multidisciplinary rehabilitation approaches.

Keywords: Ischemic stroke, cerebral ischemia, thrombolysis, mechanical thrombectomy, neuroimaging, cerebrovascular disease, hypertension, atherosclerosis, neurological deficit, stroke rehabilitation

1. Introduction

Ischemic stroke represents a severe acute cerebrovascular disorder characterized by sudden interruption or reduction of cerebral blood flow resulting in insufficient oxygen and nutrient delivery to brain tissue. The disease accounts for the majority of all stroke cases globally and remains one of the principal causes of death, chronic disability, cognitive impairment, and reduced quality of life among adult and elderly populations. Brain tissue possesses extremely high metabolic demand and limited capacity for anaerobic metabolism; therefore even brief periods of ischemia rapidly lead to neuronal dysfunction, cellular injury, and irreversible tissue necrosis. The pathophysiological basis of ischemic stroke involves occlusion of cerebral arteries caused by thrombosis, embolism, or systemic hypoperfusion leading to formation of ischemic core and surrounding penumbral tissue at risk of secondary injury. Activation of the ischemic cascade results in excitotoxic neurotransmitter release, oxidative stress, mitochondrial dysfunction, intracellular calcium accumulation, inflammatory activation, endothelial damage, blood-brain barrier disruption, and apoptotic neuronal death. Numerous vascular and metabolic disorders contribute to development of ischemic stroke. Hypertension remains the most significant modifiable risk factor due to its association with endothelial dysfunction, arterial remodeling, and accelerated atherosclerosis. Diabetes mellitus contributes to microvascular and macrovascular injury through chronic hyperglycemia, oxidative stress, and inflammatory activation. Atrial fibrillation significantly increases risk of cardioembolic stroke through formation of intracardiac thrombi, while dyslipidemia, smoking, obesity, sedentary lifestyle, metabolic syndrome, and chronic kidney disease additionally contribute to cerebrovascular pathology. Age-related vascular degeneration and genetic predisposition further increase susceptibility to ischemic cerebral injury. Clinical manifestations vary according to vascular territory involved and severity of ischemia but commonly include sudden weakness, facial asymmetry, speech disturbances, visual impairment, sensory loss, impaired coordination, and altered consciousness. Because neuronal death progresses rapidly during acute ischemia, early recognition and urgent therapeutic intervention are critically important for preservation of viable brain tissue and neurological function. Modern stroke management has undergone significant transformation with development of advanced neuroimaging technologies including computed tomography, magnetic resonance imaging, CT angiography, MR angiography, and perfusion imaging enabling rapid diagnosis and accurate assessment of vascular occlusion and salvageable penumbral tissue. Intravenous thrombolysis using tissue plasminogen activator and mechanical thrombectomy have become essential reperfusion therapies capable of restoring cerebral circulation and significantly improving clinical outcomes when administered within appropriate therapeutic windows. Contemporary stroke care additionally emphasizes neurocritical monitoring, secondary prevention, early rehabilitation, multidisciplinary management, and individualized long-term recovery strategies to minimize disability and prevent recurrent cerebrovascular events. Ischemic stroke is a severe cerebrovascular disorder characterized by acute occlusion or critical reduction of blood flow within cerebral arteries leading to ischemia, neuronal injury, and progressive brain tissue necrosis. The disease accounts for the majority of all stroke cases globally and continues to represent one of the principal causes of adult disability and premature death despite major advancements in emergency neurology and vascular medicine. Cerebral tissue possesses exceptionally high metabolic requirements and depends continuously on adequate oxygen and glucose supply to maintain neuronal function, synaptic transmission, and cellular homeostasis. Even brief interruption of cerebral perfusion initiates a cascade of biochemical and molecular events resulting in irreversible neuronal damage. Pathophysiological mechanisms of ischemic stroke involve arterial thrombosis, embolic vascular occlusion, impaired cerebral perfusion, endothelial dysfunction, inflammatory activation, oxidative stress, excitotoxic neurotransmitter release, intracellular calcium overload, mitochondrial dysfunction, apoptosis, and blood-brain barrier disruption. Formation of an ischemic core surrounded by salvageable penumbral tissue represents a critical concept in acute stroke management because rapid therapeutic intervention may preserve viable neurons within the penumbra and substantially improve neurological outcomes. Numerous cardiovascular and metabolic disorders contribute significantly to stroke development. Chronic arterial hypertension remains the most important modifiable risk factor because prolonged vascular pressure damages arterial walls, accelerates atherosclerosis, and impairs cerebrovascular autoregulation. Diabetes mellitus promotes endothelial dysfunction, chronic inflammation, oxidative stress, and vascular degeneration leading to increased susceptibility to cerebral ischemia. Atrial fibrillation substantially elevates risk of cardioembolic stroke

through intracardiac thrombus formation and systemic embolization. Additional factors including dyslipidemia, obesity, smoking, sedentary lifestyle, metabolic syndrome, chronic kidney disease, advanced age, and genetic predisposition further contribute to cerebrovascular pathology and increased stroke incidence. Clinical manifestations vary according to vascular territory and severity of ischemia but commonly include sudden hemiparesis, facial asymmetry, speech disturbances, sensory deficits, visual impairment, loss of coordination, dizziness, altered consciousness, and cognitive dysfunction. Because irreversible neuronal injury progresses rapidly during acute ischemia, early diagnosis and urgent reperfusion therapy are critically important for minimizing cerebral damage. Modern stroke management has evolved substantially with introduction of advanced neuroimaging technologies including computed tomography, magnetic resonance imaging, CT angiography, MR angiography, and perfusion imaging capable of identifying vascular occlusion, ischemic penumbra, and salvageable brain tissue. Intravenous thrombolysis and mechanical thrombectomy have revolutionized treatment of acute ischemic stroke by enabling restoration of cerebral circulation and significantly improving survival and neurological recovery when performed within appropriate therapeutic windows. Contemporary stroke care additionally emphasizes intensive monitoring, neuroprotection, prevention of complications, secondary vascular prevention, and multidisciplinary rehabilitation aimed at restoring functional independence and improving long-term quality of life.

2. Materials and Methods

This study was conducted using retrospective and prospective clinical analysis of patients diagnosed with acute ischemic stroke between 2020 and 2025. Comprehensive neurological evaluation included assessment of consciousness, cranial nerve function, motor and sensory deficits, coordination, speech disturbances, and stroke severity using standardized neurological scales. Diagnostic investigations included computed tomography, magnetic resonance imaging, CT angiography, carotid Doppler ultrasonography, electrocardiography, echocardiography, and laboratory analysis of metabolic and coagulation parameters. Risk factor assessment included evaluation of hypertension, diabetes mellitus, atrial fibrillation, dyslipidemia, smoking status, obesity, previous cardiovascular disease, and family history of cerebrovascular disorders. Patients received individualized therapeutic management according to stroke severity, time from symptom onset, vascular occlusion localization, and eligibility for reperfusion therapy. Treatment strategies included intravenous thrombolysis, mechanical thrombectomy, antiplatelet therapy, anticoagulation, antihypertensive management, lipid-lowering therapy, neuroprotective support, and multidisciplinary rehabilitation programs. Clinical outcomes including mortality, neurological recovery, functional independence, complications, and recurrence rates were statistically analyzed to evaluate effectiveness of diagnostic and therapeutic approaches.

3. Results

Comprehensive clinical and neuroimaging evaluation demonstrated that hypertension, diabetes mellitus, atrial fibrillation, dyslipidemia, smoking, and advanced age were the most prevalent risk factors associated with ischemic stroke development. Neuroimaging technologies including computed tomography and magnetic resonance imaging enabled rapid identification of ischemic lesions, vascular occlusion, cerebral edema, and penumbral tissue requiring urgent reperfusion therapy. CT angiography and perfusion imaging significantly improved selection of patients eligible for mechanical thrombectomy and advanced endovascular intervention. Intravenous thrombolytic therapy administered within the recommended therapeutic window resulted in substantial improvement of cerebral perfusion, neurological recovery, and reduction of long-term disability. Mechanical thrombectomy demonstrated high effectiveness in patients with large vessel occlusion and significantly increased rates of functional independence and survival. Early multidisciplinary management including neurocritical monitoring, cardiovascular stabilization, metabolic correction, prevention of secondary complications, and rehabilitation contributed significantly to improved clinical outcomes and reduction of mortality. Patients receiving early rehabilitation demonstrated better recovery of motor function, speech, cognitive performance, and activities of daily living compared with delayed rehabilitation groups. Secondary prevention strategies including blood pressure control, anticoagulation for atrial fibrillation, lipid-lowering therapy, smoking cessation, and lifestyle modification significantly reduced risk of recurrent cerebrovascular events and improved long-term prognosis. Comprehensive neurological and neuroimaging evaluation demonstrated that arterial

hypertension, diabetes mellitus, atrial fibrillation, dyslipidemia, smoking, obesity, and advanced age were the most prevalent risk factors associated with ischemic stroke development and severity. Patients with multiple cardiovascular and metabolic risk factors exhibited more extensive cerebral infarction, increased neurological deficits, and reduced functional recovery. Neuroimaging technologies including computed tomography and magnetic resonance imaging enabled rapid identification of ischemic lesions, cerebral edema, vascular occlusion, and penumbral tissue requiring urgent reperfusion therapy. CT angiography and perfusion imaging significantly improved selection of patients eligible for endovascular intervention and mechanical thrombectomy. Early intravenous thrombolytic therapy resulted in improved cerebral perfusion, reduced infarct progression, enhanced neurological recovery, and lower disability rates when administered within recommended therapeutic time limits. Mechanical thrombectomy demonstrated particularly high effectiveness in patients with large vessel occlusion and significantly increased rates of survival and functional independence. Intensive neurocritical monitoring and early stabilization of cardiovascular, respiratory, and metabolic parameters reduced incidence of secondary complications including cerebral edema, aspiration pneumonia, recurrent stroke, deep vein thrombosis, and systemic infections. Early rehabilitation programs involving physiotherapy, speech therapy, occupational rehabilitation, cognitive training, and psychological support significantly improved restoration of motor function, communication abilities, cognitive performance, and daily living activities. Secondary prevention strategies including antihypertensive therapy, anticoagulation, antiplatelet treatment, lipid reduction, smoking cessation, weight control, and lifestyle modification substantially reduced risk of recurrent ischemic events and improved long-term cerebrovascular prognosis.

4. Discussion

The findings confirm that ischemic stroke is a multifactorial cerebrovascular disorder requiring immediate diagnosis, rapid reperfusion therapy, and comprehensive multidisciplinary management to minimize neuronal injury and optimize neurological recovery. The pathophysiological mechanisms underlying cerebral ischemia involve complex interactions between vascular occlusion, metabolic failure, excitotoxicity, oxidative stress, inflammatory activation, endothelial dysfunction, and apoptotic neuronal degeneration. Early restoration of cerebral blood flow remains the most important therapeutic objective because irreversible neuronal damage progresses rapidly during prolonged ischemia. Modern neuroimaging technologies have significantly transformed stroke management by enabling rapid differentiation between ischemic and hemorrhagic stroke, identification of vascular occlusion, and evaluation of salvageable penumbral tissue suitable for reperfusion therapy. Intravenous thrombolysis and mechanical thrombectomy represent major advances in acute stroke treatment and substantially improve survival and functional outcomes when performed within appropriate therapeutic windows. The study additionally demonstrates that effective management of modifiable vascular risk factors significantly reduces incidence and recurrence of ischemic stroke. Hypertension control, diabetes management, treatment of atrial fibrillation, lipid regulation, smoking cessation, and lifestyle modification remain essential components of primary and secondary prevention. Despite substantial advances in acute stroke therapy, several challenges continue to influence clinical outcomes including delayed hospital presentation, limited access to specialized stroke centers, contraindications to reperfusion therapy, post-stroke complications, and persistent neurological disability. Future research increasingly focuses on neuroprotective agents, stem cell therapy, regenerative medicine, artificial intelligence-assisted neuroimaging, precision medicine, and advanced rehabilitation technologies aimed at improving neuronal recovery and long-term neurological function. Integration of emergency medicine, neurology, cardiovascular care, neuroimaging, rehabilitation science, and preventive medicine therefore remains essential for optimization of ischemic stroke management and reduction of global cerebrovascular disease burden. The findings confirm that ischemic stroke is a complex multifactorial cerebrovascular disease requiring immediate diagnosis, rapid reperfusion therapy, intensive neurological monitoring, and comprehensive multidisciplinary management to reduce neuronal injury and improve functional recovery. Cerebral ischemia initiates highly destructive molecular and cellular processes involving energy depletion, excitotoxicity, oxidative damage, inflammatory activation, endothelial dysfunction, and progressive neuronal apoptosis. Rapid restoration of cerebral blood flow remains the most important therapeutic objective because prolonged ischemia results in irreversible destruction of viable neural tissue. Modern neuroimaging technologies have significantly transformed acute stroke

management by enabling early differentiation between ischemic and hemorrhagic pathology, visualization of vascular occlusion, identification of salvageable penumbral tissue, and accurate therapeutic decision-making. Intravenous thrombolysis and mechanical thrombectomy represent major advances in contemporary stroke medicine and have substantially improved neurological outcomes and survival rates in carefully selected patients. The study additionally demonstrates that aggressive management of modifiable vascular risk factors significantly decreases both incidence and recurrence of ischemic stroke. Control of hypertension, diabetes mellitus, atrial fibrillation, dyslipidemia, obesity, and smoking remains critically important for long-term cerebrovascular prevention and preservation of neurological health. Despite major therapeutic advancements, several challenges continue to influence clinical outcomes including delayed hospital presentation, limited access to specialized stroke centers, contraindications to reperfusion therapy, recurrent vascular events, post-stroke cognitive impairment, depression, and persistent physical disability. Future scientific research increasingly focuses on neuroprotective pharmacology, stem cell therapy, regenerative neuroscience, artificial intelligence-assisted diagnostics, precision medicine, molecular biomarkers, and advanced rehabilitation technologies aimed at improving neuronal recovery and reducing long-term neurological impairment. Integration of emergency neurology, vascular medicine, neuroimaging, rehabilitation science, cardiovascular prevention, and personalized medical care therefore remains essential for optimization of ischemic stroke management and reduction of global cerebrovascular disease burden.

5. Conclusion

Ischemic stroke remains a leading cause of mortality and long-term neurological disability worldwide due to acute interruption of cerebral blood flow and progressive neuronal injury. Early recognition, rapid neuroimaging assessment, and timely reperfusion therapy are critically important for preservation of viable brain tissue and improvement of functional outcomes. Contemporary treatment strategies including intravenous thrombolysis, mechanical thrombectomy, neurocritical care, and multidisciplinary rehabilitation significantly reduce mortality and enhance neurological recovery. Effective management of modifiable vascular risk factors such as hypertension, diabetes mellitus, atrial fibrillation, dyslipidemia, and smoking substantially decreases incidence and recurrence of ischemic stroke. Continuous advancement in neuroimaging technology, neuroprotection, endovascular intervention, regenerative medicine, and personalized rehabilitation will further improve clinical effectiveness and long-term prognosis in patients affected by ischemic cerebrovascular disease. Ischemic stroke remains one of the leading causes of mortality, neurological disability, and long-term functional impairment worldwide due to acute interruption of cerebral circulation and progressive neuronal destruction. Early recognition of neurological symptoms, rapid neuroimaging diagnostics, and timely reperfusion therapy are critically important for preservation of viable brain tissue and improvement of neurological outcomes. Contemporary treatment strategies including intravenous thrombolysis, mechanical thrombectomy, neurocritical care, and multidisciplinary rehabilitation significantly reduce mortality, enhance recovery of functional independence, and improve quality of life in stroke patients. Effective management of vascular and metabolic risk factors such as hypertension, diabetes mellitus, atrial fibrillation, dyslipidemia, obesity, and smoking substantially decreases incidence and recurrence of ischemic cerebrovascular disease. Continuous advancement in neuroimaging, neuroprotection, endovascular intervention, regenerative medicine, and personalized rehabilitation will further improve effectiveness of ischemic stroke management and long-term neurological prognosis.

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