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# 21

# Rehabilitation of Younger Patients Post Stroke

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## Abstract

The young stroke population represents a significant rehabilitation challenge. When compared to older patients, young patients are more often employed, caring for dependants, and relying on work-related income. Although much less common than in older patients, stroke in young adults has an annual incidence rate from 6 to 20 per 100,000 individuals annually (Leys et al., 2002). One of every five individuals who experience a stroke is under the age of 65, while 5% of all these individuals are younger than 45 years old. This represents a significant number of patients with some unique rehabilitation needs (Dixon et al., 2007; Stone, 2007). This chapter reviews current research pertaining to incidence, risk, etiology, recovery, prognosis, and rehabilitation of stroke in younger patients. Additional topics relevant to the young stroke population are also featured: return to work, family stress, institutionalization, patient perceptions of care, and future needs.

## Key Points

- The incidence of stroke in young patients is considerably lower than in older patients, but has increased over time and varies considerably between cohorts.
- Approximately one third of strokes in young people are of unknown etiology.
- Hypertension, arteriovenous malformation, and ruptured aneurysms are the most common causes for hemorrhagic strokes in young individuals.
- The majority of strokes in young patients are ischemic, which are commonly caused by cardiac embolism or atherosclerosis.
- Patients under the age of 30 experience more uncommon stroke etiologies. Potential causes of young strokes are likely due to genetic factors or pre-existing conditions that increase the risk of strokes.
- Modifiable risk factors for stroke include smoking, hypertension, hyperlipidemia, diabetes mellitus, excessive alcohol consumption, and drug use, as well as oral contraceptive use and migraine with aura in women.
- Non-modifiable risk factors for stroke include sex, race, previous stroke, family history of stroke, atrial fibrillation, mitral valve prolapse, patent foramen ovale, and pregnancy/postpartum in young females.
- Young patients have better recovery and prognosis compared to older patients following stroke.
- Stroke rehabilitation of younger patients differs from the more traditional rehabilitation of older patients because of better likelihood of neurological recovery and unique social issues for younger patients.
- Improved recovery of young patients post stroke tends to put less stress on caregivers. However, caregiver struggles are often associated with changes in relationships and difficulty adjusting.
- Institutionalization is required infrequently in young patients post stroke, and is generally associated with severe stroke and limited social support.
- Vocational issues are often neglected in stroke rehabilitation of young patients. These issues are influenced by job type, cognitive ability, functional recovery, and stroke severity.
- Young patients tend to have unique psychosocial and supportive needs post stroke rather than specific health concerns.

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## 21.1 Incidence

Stroke is generally considered to be a condition that occurs in elderly individuals (Teasell et al., 2000). The mean age for acute stroke is over 70 years in industrialized countries. Stroke also occurs in younger adults (age <50), with an incidence rate from 6 to 20 per 100,000 individuals annually (Leys et al., 2002). For every 5 individuals who experience a stroke, 1 is under the age of 65, while 5% of all stroke patients have been found to be younger than 45 years of age. Moreover, stroke incidence for patients under 75 years old has increased over time (Johansson et al., 2000). These findings demonstrate a significant number of young patients who have unique rehabilitation needs following stroke (Dixon et al., 2007; Stone, 2007).

The incidence of stroke in young individuals is significantly less than in older individuals (Ghandehari & Moud, 2006). Incidence for individuals below the age of 50 have ranged from 3/100,000 to 44.3/100,000 (Bonita et al., 1984; Cabral et al., 2009; Corso et al., 2009; Ghandehari & Moud, 2006; Harmsen et al., 2009; Jacobs et al., 2002; Marini et al., 2001; Rasura et al., 2006). These rates are substantially lower compared to those of older individuals, which were found anywhere from 3/1,000 to 25/1,000. A review by Marini et al. (2010) reported incidence rates of stroke in younger individuals (<45 years of age) standardized to the 2000 European population: ranging from 6.14/100,000 to 48.51/100,000 per year or 8.70/100,000 to 21.10/100,000 per year once outliers had been removed. For individuals between the ages of 50 and 64 years, stroke occurs at a rate of approximately 3/1,000 persons, which quadruples to approximately 12/1,000 for those between the ages of 65 and 74 years and then doubles to approximately 25/1,000 for those 80 years and older (Abu-Zeid et al., 1975; Bonita, 1992; Bonita et al., 1984; Mayo et al., 1991; Shah & Bain, 1989).

The annual incidence rates were found to differ between young males and females post stroke. Naess et al. (2002) found a marginally greater incidence rate among younger patients with first ever cerebral infarct, favouring males (12.9/100,000) compared to females (9.7/100,000). Similarly, Kang et al. (2011) found that the incidence of first-ever stroke was 176/100,000 among males aged 45 to 54 years versus 113/100,000 among females of the same age group. Studies have also compared the incidence of stroke in young adults over time. One study found that incidence increased from 1992 to 2012, with the greatest increase in individuals between the ages of 45 and 64, with a slightly lower increase in individuals less than 45 years (Wang et al., 2015). Another study showed a decreasing incidence rate over time, with a significant decrease in the crude incidence of individuals aged 0-29 years from 5.1 in 2006 to 4.3 in 2010 (Kim et al., 2013).

Both physical and cognitive abilities are impacted by stroke, which in turn affects quality of life (Keppel & Crowe, 2000; O'Connor et al., 2005; Röding, 2009). Younger individuals are often at a stage in their life where employment is important, and they are more likely to be caring for children. Rehabilitation strategies for elderly patients are not always applicable for younger patients (Stone, 2005). Few studies have assessed the specific needs of young patients post stroke (Low et al., 2003), with limited insight from young individuals' viewpoints on the recovery process (Dixon et al., 2007; Low et al., 2003; Stone, 2005). Consequently, the needs of young patients are often not being addressed within the context of inpatient stroke rehabilitation, which tends to focus on older patients (Röding et al., 2003; Stone, 2005).

Stroke in younger patients has become a major socioeconomic issue (Bjorkdahl & Sunnerhagen, 2007; Mehndiratta et al., 2004), as survivors have a longer time to live with their physical and cognitive impairments. The cost of stroke in young people exceeds that of stroke in older people due to a loss in productivity and more psychosocial complications (Jacobs et al., 2002; Nayak et al., 1997). These complications include family stress, return to work, institutionalization, and ongoing care (Teasell et al.,

2000). The rehabilitation of young patients following stroke presents distinct challenges in achieving the best possible outcomes.

***Conclusions Regarding Incidence of Stroke in Younger Individuals***

***The incidence of stroke in young patients varies considerably across reports, ranging from 3 to 44 out of 100,000.***

***The incidence of stroke in young patients is notably lower than in older patients.***

***The incidence of stroke in young patients has increased over time.***

***The incidence of stroke in young patients is considerably lower than in older patients, but has increased over time and varies considerably between cohorts.***

## 21.2 Etiology

Stroke in younger populations tend to have a wider variety of etiologies than older stroke cohorts. Unique to young patients is a higher percentage of stroke that is of undetermined causes (Guercini et al., 2008). Among cohorts of young strokes (<55), unusual etiologies are more prevalent in those <35 years of age, whereas those between 35-55 years of age are more likely to be diagnosed with etiologies more common to older patients (Jacobs et al. 2002). As well, hemorrhagic strokes occur more frequently in younger populations (Ruiz-Sandoval et al., 2006).

### 21.2.1 Undetermined Etiology

Previous studies suggest that a cause for stroke cannot be determined for up to one-third of young patients (Chancellor et al., 1989; Kittner et al., 1999; Kittner et al., 1998; Rasura et al., 2006; Wityk et al., 2000). However, variations in definition and classification of "unknown etiology" may affect this estimate (Guercini et al., 2008). For instance, Awada (1994) separated unknown causes from uncertain causes, while Varona et al. (2007) divided undetermined etiologies on the basis of complete versus incomplete evaluations. Moreover, Lai et al. (2005) included pre-examination mortality with unknown etiology, and designated cryptogenic etiology for patients without risk factors. These studies suggest that incomplete investigations or a lack of patient information may incorrectly assume an unknown cause of stroke in some studies.

Multiple studies have analyzed trends in the prevalence of undetermined stroke. In a longitudinal study, Varona et al. (2007) reported that the number of cryptogenic diagnoses from 1974-1988 compared to 1989-2002 decreased by 19%. The number of strokes with an undetermined etiology due to incomplete evaluation also decreased by 38% (Varona et al., 2007), which was attributed to improved diagnostic tools and methods. Similarly, Balci et al. (2011) reported a decreased frequency of undetermined etiology when their population was compared to the literature; this was believed to be a result of more extensive diagnostic evaluations.

The prevalence of undetermined etiology was also higher among younger individuals compared to older individuals. For instance, of those aged 18-35, 66% had unknown etiology (Dash et al., 2014), while a diagnosis of unknown etiology in those aged over 36 ranged from 20.9% to 52.9% (Barlas et al., 2013; Dash et al., 2014; Eun et al., 2013). Lastly, in a comparison of undetermined etiology between males and females, Dash et al. (2014) reported a difference of 37.2% in favour of males. Although this difference

was statistically significant, the authors suggested that this difference may have been affected by the 5:1 male to female ratio.

***Conclusions Regarding Undetermined Stroke Etiology***

***Up to one third of strokes in young people are of unknown etiology. However, this proportion is decreasing as diagnostic methods improve.***

***Approximately one third of strokes in young people are of unknown etiology.***

### 21.2.2 Hemorrhagic Etiology

Intracerebral hemorrhage (ICH) and subarachnoid hemorrhage (SAH) together constitute approximately 30-35% of all strokes in patients under the age of 50 (Awada, 1994; Jacobs et al., 2002; Teasell et al., 2000). This rate appears to be significantly higher than the 15-20% incidence reported for patients over the age of 50 (Abu-Zeid et al., 1975; Awada, 1994). Moreover, the majority of young patients with hemorrhagic stroke are aged between 30 and 50 (Lai et al., 2005; Mehndiratta et al., 2004; Ruiz-Sandoval et al., 2006). There is a large degree of overlap in the cause of bleeding between the subtypes of hemorrhagic stroke in young patients. Meyer (1994) listed the following possible causes for ICH in young patients: arteriovenous malformations (AVM), aneurysm, hypertension (HTN), blood disorders, brain tumors, and inflammation of blood vessels and veins.

**Table 21.2.2.1 Etiologies of Hemorrhagic Stroke in Young Patients**

| Author, Year | Sample Size (Age Range) | Most Common Etiologies (%) |
|---|---|---|
| Awada (1994) | 120 (15-45) | 1. HTN (27)<br>2. AVM (26.5) |
| Ruiz-Sandoval et al. (1999) | 200 (15-40) | 1. AVM (49)<br>2. HTN (11) |
| Mehndiratta et al. (2004) | 127 (15-40) | 1. Aneurysm (44.4)<br>2. AVM (21.2), HTN (21.2) |
| Lai et al. (2005) | 296 (15-45) | 1. HTN (46.7)<br>2. AVM (16.9) |
| Rutten-Jacobs et al. (2013b) | 724 (18-50) | 1. HTN (23.5)<br>2. AVM (20.6) |
| Kalita et al. (2014) | 404 (16-50) | 1. HTN (79.2)<br>2. Cryptogenic (9.2) |

When examining hypertension (HTN) as the etiology of ICH in young patients, race was found to be an influential factor (Chong & Sacco, 2005a). Qureshi et al. (1995) found that 64% of Black patients had HTN-caused ICH, whereas Ruiz-Sandoval et al. (2006) reported that only 11% of young Latino patients had ICH attributable to HTN. Kalita et al. (2014) observed HTN-caused ICH in 79.2% of participants in an Indian population, which was drastically higher than the 11% to 46.6% range reported in other studies. However, the authors suggested that the difference may have been due to the higher prevalence of HTN in the surveyed Indian population compared to previously studied Western populations. HTN is more commonly associated with ICH among younger stroke patients than in persons over age 45 with ICH (Chong & Sacco, 2005b; Ruiz-Sandoval et al., 2006). This trend peaks significantly for those in the 35-45 age range (Lai et al., 2005). Similar to HTN, AVM is commonly found to cause ICH in the second and third decade of life (Meyer et al., 1994).

As previously mentioned, the majority of SAH etiologies in young patients overlap with those of ICH. Additional etiologies associated with SAH are trauma and eclampsia in young women (Meyer et al., 1994). Mehndiratta et al. (2004) found the most common cause of SAH to be a ruptured aneurysm (66.6%), followed by AVM (33.3%). As well, Bevan et al. (1990) found that 41% of SAH in young people were caused by a ruptured aneurysm.

***Conclusions Regarding Hemorrhagic Stroke***

***The most common causes for hemorrhagic stroke in young patients include hypertension, arteriovenous malformation, ruptured aneurysm, or a combination of these factors.***

***Hypertension, arteriovenous malformation, and ruptured aneurysms are the most common causes for hemorrhagic strokes in young individuals.***

### 21.2.3 Ischemic Etiology

Individuals under the age of 45 account for fewer than 5% of the total number of ischemic infarcts (Kristensen et al., 1997). However, ischemic cerebral infarctions are the predominant subtype of stroke for the younger population, with 47-85% of young stroke events recognized as ischemic (Awada, 1994; Mehndiratta et al., 2004; Meyer et al., 1994). Between the ages of 40-49, there is a dramatic increase in the number of strokes, which can be partially accounted for by an increase in advanced atherosclerosis (Ferro & Crespo, 1988; Siqueira Neto et al., 1996; Williams et al., 1997). In patients younger than 45 years old, Li et al. (2015) found an incidence of 21.9% associated with ischemic stroke compared to an incidence of 19.4% with hemorrhagic stroke.

Multiple studies have classified the etiology of ischemic stroke in young participants, although the results are often inconsistent. A study of 300 consecutive patients under the age of 40 with cerebral infarction found that premature atherosclerosis accounted for only 3% of the strokes (Barinagarrementeria et al., 1996). However, in a prospective study of 286 patients aged 15-45 with a cerebral infarction, Love and Biller (1990) found that an atherosclerotic etiology was implicated in 27% of cases. Similarly, in a retrospective study of 254 patients under the age of 50 years, Ferro and Crespo (1988) found that 35% of all strokes could be attributed to atherosclerosis. In one study, for patients younger than 40 years of age, cardiac embolism was the most common cause of ischemic stroke (Ferro & Crespo, 1988; Hart & Miller, 1983). In contrast, recent studies comparing etiological differences between age groups observed a significantly greater proportion of cardioembolic strokes in older patients, with a difference ranging from 3% to 15.8% (Barlas et al., 2013; Dash et al., 2014; Khealani et al., 2014; Smajlović, 2015).

***Conclusions Regarding Ischemic Stroke***

***The majority of strokes in young patients are ischemic. Cardiac embolism is a common cause for patients younger than 40, while atherosclerosis is a common cause for patients aged 40-49.***

***The majority of strokes in young patients are ischemic, which are commonly caused by cardiac embolism or atherosclerosis.***

### 21.2.4 Uncommon Etiologies

Strokes are uncommon in individuals under the age of 45, and are even more uncommon under the age of 30. Stroke etiology of both hemorrhagic and ischemic strokes in individuals under the age of 30 is

generally related to unknown or unusual causes. Hematological disorders, developmental cardiac abnormalities, chronic systemic inflammation, and hypercoagulable state are all documented possibilities (Bevan et al., 1990; Ha et al., 2009; You et al., 1997). Some uncommon etiologies are also recognized as risk factors for stroke in young patients: drug and alcohol use, oral contraceptives, migraines, non-atherosclerotic vasculopathy, plasma homocysteine level, mitral valve prolapse, multifocal intracranial stenosis, monoarterial intracranial stenosis, extracranial dissection, cardiac disease, and polymorphis (Bendixen et al., 2001; Bos et al., 2005; Hankey, 2012; Hillbom et al., 1995; Kittner et al., 1999; Kristensen et al., 1997; Munshi et al., 2011; Vassilopoulou et al., 2011; Westover et al., 2007; Wityk et al., 2000; Wolff et al., 2011).

In a study by Dash et al. (2014), the prevalence of uncommon etiologies in young patients was investigated. The authors studied the etiology of stroke in 440 patients aged 18-45 years and found that the cause of 17.3% of strokes was classified as "other". They suggested that this finding was mainly attributed to strokes being more uncommon in young individuals, allowing for rare and genetic causes to prevail in young populations. Multiple studies have also directly compared uncommon etiologies between young and old patients (Barlas et al., 2013; Chen et al., 2013; Dash et al., 2014; Eun et al., 2013; Khealani et al., 2014; Renna et al., 2014; Smajlović, 2015). Generally, uncommon etiologies were more prevalent in younger patients, with the difference ranging from 0.4% when comparing patients 18-35 years to 36-45 years, to 6.7% when comparing patients greater than and less than 45 years.

***Conclusions Regarding Uncommon Stroke Etiologies***

***Uncommon etiologies are likely in stroke patients under the age of 30.***

***There are many uncommon etiologies that have been recognized as risk factors for stroke in young patients, including but not limited to migraines, non-atherosclerotic vasculopathy, mitral valve prolapse, multifocal intracranial stenosis, extracranial dissection, and cardioembolism.***

***Patients under the age of 30 experience more uncommon stroke etiologies. Potential causes of young strokes are likely due to genetic factors or pre-existing conditions that increase the risk of strokes.***

### 21.2.5 Summary

Stroke among young adults is uncommon but does occur (Awada, 1994; Mehndiratta et al., 2004; Meyer et al., 1994). The majority of stroke in young people are cerebral infarctions, which are often caused by cardiac embolism for patients younger than 40 (Ferro & Crespo, 1988; Hart & Miller, 1983) and advanced atherosclerosis for patients aged 40 to 49 years (Ferro & Crespo, 1988; Siqueira Neto et al., 1996; Williams et al., 1997). Proportionally, hemorrhagic and unknown causes of stroke are higher in the younger population (Jacobs et al., 2002; Lai et al., 2005; Mehndiratta et al., 2004; Ruiz-Sandoval et al., 2006). Diagnosis of "undetermined causes" accounts for up to one third of strokes in individuals under the age of 45 (Awada, 1994; Rasura et al., 2006) and up to 66% in patients aged 18-35 years with first-ever ischemic stroke (Barlas et al., 2013). Typical etiologies for hemorrhagic stroke include arteriovenous malformation, ruptured aneurysm, hypertension, or a combination of these factors. Uncommon etiologies are likely in stroke patients under 30 years (Bendixen et al., 2001; Varona et al., 2007) and tend to be more prevalent in young patients compared to older patients (Barlas et al., 2013; Chen et al., 2013; Dash et al., 2014; Eun et al., 2013; Renna et al., 2014; Smajlović, 2015). However, many of these uncommon etiologies are recognized as both possible etiologies and risk factors.

## 21.3 Risk Factors

While stroke in the young population is rare, the odds of a stroke event may increase if a patient exhibits one or more risk factors. Risk factors can be categorized as modifiable or non-modifiable. The modifiable risk factors discussed are diet, smoking, alcohol, drug use, oral contraceptives, migraine, hypertension, hyperlipidemia, diabetes mellitus, plasma homocysteine level, and chlamydia pneumoniae. The non-modifiable risk factors discussed are sex, race, previous stroke, family history of stroke, atrial fibrillation, mitral valve prolapse, patent foramen ovale, and pregnancy. Many of these risk factors are discussed in Chapter 8: Secondary Prevention of Stroke.

### 21.3.1 Modifiable Risk Factors

#### Diet

Lifestyle factors link stroke to diet. Decreased stroke rates are related to high intakes of whole grains, fruits, and vegetables, whereas increased rates of stroke can be associated with factors such as alcohol consumption (Agnoli et al., 2011). In a prospective study design, Agnoli et al. (2011) investigated the association between stroke and adherence to four dietary patterns: Healthy Eating Index 2005 (HEI-2005), Dietary Approaches to Stop Hypertension (DASH), Greek Mediterranean Index (GMI), and the Italian Mediterranean Index (IMI). The study assessed the dietary patterns of 40,681 volunteers and conducted a follow-up at a mean of 8 years. There were 178 diagnosed stroke cases reported: 100 ischemic and 47 hemorrhagic (Agnoli et al., 2011). All dietary patterns, other than the HEI-2005, were associated with reduced risk of stroke, with the IMI showing the strongest association (HR=0.47, 95% CI 0.30-0.75). Ischemic stroke incidence was reduced with all dietary patterns included in the study, except the GMI, with the IMI showing the strongest association (HR=0.37, 95% CI 0.19-0.70). Hemorrhagic stroke incidence was only reduced with the IMI (HR = 0.51; 95% CI 0.22–1.20). The IMI features high intakes of typical foods (e.g. vegetables, fruit, legumes, pasta, olive oil, fish) and low intakes of alcohol and non-typical foods (e.g. soft drinks, red meat, butter, potatoes). These findings suggest that dietary patterns can influence stroke, with the IMI being the dietary pattern associated with the largest reduction in risk for stroke (Agnoli et al., 2011).

Another study that examined the effect of nutrition on stroke etiology proposed that both malnutrition and over-nutrition can have an effect on stroke prevalence (Hankey, 2012). An association of poor growth in the first two years of life, due to malnutrition, was associated with an increased risk of stroke in adulthood (Hankey, 2012). Over-nutrition and the effects of specific nutrients were also associated with different risks depending on the nutrient. For instance, salt supplementation by 5 g per day was associated with a 23% increased risk of stroke, whereas potassium supplementation by 1 g per day was associated with an 11% reduction in the risk of stroke (Hankey, 2012).

#### Smoking

Smoking is reported to be a significant risk factor for stroke among younger populations (Lu et al., 2008; Rasura et al., 2006; Ruiz-Sandoval et al., 2006; Spengos & Vemmos, 2010; You et al., 1997). In fact, recent studies have observed that smoking is the most common risk factor, found in approximately half or more of the studied stroke population (Arntz et al., 2015; Bejot et al., 2014; Chatzikonstantinou et al., 2012; Putaala et al., 2012; Tsivgoulis et al., 2014; Von Sarnowski et al., 2013).

In Western populations, smoking was listed as a risk factor for stroke in both young female and young male patients (Kristensen et al., 1997; Ruiz-Sandoval et al., 2006). In contrast, Lee et al. (2002) and Kwon et al. (2000) found smoking to be dramatically higher (>50%) in young male patients as opposed to young female patients living in Asia. Although the difference was not as drastic, Dash et al. (2014) found

smoking to be 2.2% more prevalent in males when assessing patients 18-45 years in an Indian population.

When compared to an older population, Fromm et al. (2011) found a significantly higher percentage of young stroke patients had current smoking as a risk factor. Similar results were found for multiple studies with higher smoking rates, ranging from 16.9% to 27.6% between younger and older patients (Chen et al., 2013; Dash et al., 2014; Park et al., 2014; Smajlovic et al., 2013). However, some studies have found instances where smoking is more prevalent in older patients (Goeggel Simonetti et al., 2015; Khealani et al., 2014; Renna et al., 2014).

**Table 21.3.1.1 Smoking Prevalence in Young Strokes**

| Author, Year | Sample Size (Age Range) | Stroke Type | Prevalence of Risk Factor |
|---|---|---|---|
| Adams et al. (1986) | 144 (15-45) | Ischemic | 21% |
| Awada (1994) | 120 (15-45) | Ischemic 58.5%, Hemorrhagic 41.5% | 26% |
| Barinagarrementeria et al. (1996) | 300 (<40) | Ischemic | 24% |
| You et al. (1997) | 201 (15-55) | Ischemic | 56% |
| Nayak et al. (1997) | 177 (15-45) | Ischemic | 47% |
| Ruiz-Sandoval et al. (1999) | 200 (15-40) | Hemorrhagic | 20.5% |
| Camerlingo et al. (2000) | 135 (16-45) | Ischemic | 23.7% |
| Kwon et al. (2000) | 149 (15-44) | Ischemic | 51% |
| Lee et al. (2002) | 264 (18-45) | Ischemic | 49.8% |
| Schwaag et al. (2003) | 160 (15-45) | Ischemic 88.7%, TIA 11.3% | 54% |
| Musolino et al. (2003) | 60 (17-45) | Ischemic 92%, TIA 8% | 46.7% |
| Mehndiratta et al. (2004) | 127 (15-40) | Ischemic 85.5%, Hemorrhagic 14.5% | 15.9% |
| Nedeltchev et al. (2005) | 203 (16-45) | Ischemic | 46% |
| Carod-Artal et al. (2005) | 130 (15-45) | Ischemic | 24.6% |
| Lai et al. (2005) | 296 (15-45) | Hemorrhagic | 38% |
| Rasura et al. (2006) | 394 (14-47) | Ischemic | 56% |
| Ruiz-Sandoval et al. (2006) | 35 (18-40) | Hemorrhagic | 14% |
| Lipska et al. (2007) | 214 (15-45) | Ischemic | 37% |
| Varona et al. (2007) | 272 (15-45) | Ischemic | 49% |
| Rallidis et al. (2008) | 135 (≤35) | Ischemic | 94.8% |
| Jovanović et al. (2008) | 865 (15-45) | Ischemic | 37% |
| Arnold et al. (2008) | 137 (<45) | Ischemic | 39% |
| Onwuchekwa et al. (2009) | 54 (18-45) | Ischemic 64.8%, Hemorrhagic 35.2% | 11.1% |
| Putaala et al. (2009b) | 1008 (15-49) | Ischemic | 44.2% |
| Bi et al. (2010) | 1988 (35-45) | Ischemic 94.3%, Hemorrhagic 5.7% | 38.8% |
| Spengos and Vemmos (2010) | 253 (≤45) | Ischemic | 59.3% |
| Tan et al. (2010) | 67 (>50) | Ischemic | 21.4% |
| | 61 (>50) | Ischemic | 44.2% |
| Balci et al. (2011) | 192 (18-47) | Ischemic | 37% |
| Dharmasaroja et al. (2011) | 12 (15-30) | Ischemic, TIA | 25% |
| | 25 (31-40) | Ischemic, TIA | 56% |
| | 62 (41-50) | Ischemic, TIA | 42% |
| Fromm et al. (2011) | 100 (<50) | Ischemic | 41% |
| Janssen et al. (2011) | 95 (<50) | Ischemic 51%, TIA 49% | 40% |
| Patella et al. (2011) | 98 (14-45) | Ischemic | 47.9% |

| | | | |
|---|---|---|---|
| De Los Rios et al. (2012) | 501 (18-54) | Ischemic 69%, Hemorrhagic 22%, Unknown 9% | 18-34yr: 36%<br>35-44yr: 55%<br>45-54yr: 53% |
| Putaala et al. (2012) | 3944 (18-49) | Ischemic | 49% |
| Chatzikonstantinou et al. (2012) | 104 (19-45) | Ischemic | 55.2% |
| Arntz et al. (2013)<br>Arntz et al. (2013)<br>Arntz et al. (2015) | 697 (18-50) | Ischemic 61%, TIA 29.6%, Hemorrhagic 9.5% | 61.8% |
| Calviere et al. (2013) | 100 (16-55) | Ischemic | 45% |
| Chen et al. (2013) | 973 (20-64; 65-98) | Ischemic | <65yr: 44.8%<br>≥65yr: 23.8% |
| Dharmasarjoa et al. (2013) | 261 (≤60) | Ischemic | 28% |
| Rolfs et al. (2013) | 3396 (18-55) | Ischemic 76%, TIA 16%, Hemorrhagic 8%, Other 1.4% | 18-24yr: 37.3%<br>25-34yr: 35.9%<br>35-44yr: 40.9%<br>45-55yr: 42.7% |
| Smajlovic et al. (2013) | 3864 (<45; ≥45) | Ischemic 79.9%, Hemorrhagic 20.1% | <45yr: 55.8%<br>≥45yr: 28.4% |
| Tiamkao et al. (2013) | 85 (<45) | — | 37.6% |
| Von Sarnowski et al. (2013) | 4467 (18-55) | Ischemic, TIA | 55.5% |
| Aarnio et al. (2014) | 970 (15-49) | Ischemic | 44.8% |
| Béjot et al. (2014) | 4506 (<55) | — | 1985-1993: 57.3%<br>1994-2002: 37.3%<br>2003-2011: 57.9% |
| Bugnicourt et al. (2014) | 104 (<60) | Ischemic, TIA | 43% |
| Chraa et al. (2014) | 128 (18-45) | Ischemic | 40.6% |
| Dash et al. (2014) | 440 (18-45) | Ischemic | 9.5% |
| Kalita et al. (2014) | 404 (16-50) | Hemorrhagic | 13.9% |
| Khealani et al. (2014) | 874 (16-45; >45) | Ischemic | 16-45yr: 18.3%<br>>45yr: 14.4% |
| Maaijwee et al. (2014) | 437 (18-50) | Ischemic | 25.6% |
| Palmcrantz et al. (2014) | 150 (18-64) | Ischemic 80%, Hemorrhagic 17%, Other 3% | 33% |
| Park et al. (2014) | 25818 (15-45) | Ischemic | 47.8% |
| Renna et al. (2014) | 150 (<50) | Ischemic | 47.3% |
| Shi et al. (2014) | 351 (≤55) | Ischemic | 35.5% |
| Tsivgoulis et al. (2014) | 1134 (18-45) | Ischemic 85.7%, Hemorrhagic 14.3% | 50.5% |
| Zhang et al. (2014) | 381 (18-45) | Ischemic | 43.5% |
| Cruz-Herranz et al. (2015) | 102 (<45) | Ischemic 62.7%, TIA 23.5%, Hemorrhagic 2%, Other 11.8% | 40.4% |
| Koivunen et al. (2015) | 336 (<50) | Hemorrhagic | 22.3% |
| Maaijwee et al. (2015) | 511 (18-50) | Ischemic 63.7%, TIA 36.3% | 21.1% |
| Park et al. (2015) | 4747 (18-90) | Ischemic | 20-45yr: 33.3%<br>45-65yr: 26.6%<br>≥66yr: 16.5% |
| Simonetti et al. (2015) | 624 (16-55) | Ischemic, Hemorrhagic | 16-45yr: 41%<br>46-55yr: 45% |
| González-Gómez et al. (2016) | 110 (<55) | Ischemic, Hemorrhagic | 56.4% |

## Alcohol

Alcohol-related stroke events in young patients are relative to the amount consumed. Light to moderate alcohol intake has been shown to reduce the risk of stroke whereas high intake, or alcohol abuse, can increase the risk of stroke (particularly hemorrhagic) (Bruno, 2003; Hillbom et al., 1995; Lu et al., 2008). In a study by Naess et al. (2013), the authors compared the prevalence of risk factors in a young stroke population between patients deceased or surviving at a mean of 18 years post stroke. They found that deceased patients had a 20.9% greater prevalence of alcoholism compared to surviving patients. A review of alcohol-related stroke in young patients found ischemic stroke was reduced by up to 40% in those who consumed one to two alcoholic beverages daily (Bruno, 2003).

Risk of hemorrhagic stroke was found to increase 1.9 to 4.6 times if patients consumed more than one alcoholic beverage daily, which was likely due to increased blood pressure associated with heavy drinking (Gillman et al., 1995). Similar results were reported from an 11-year prospective cohort study of 45,449 women under the age of 60 (Lu et al., 2008). Compared with non-drinkers, women who consumed alcohol had a decreased risk of stroke, regardless of the beverage type (Lu et al., 2008).

**Table 21.3.1.2 Alcohol Use Prevalence in Young Stroke**

| Author, Year | Sample Size (Age Range) | Stroke Type | Prevalence of Risk Factor |
|---|---|---|---|
| Hillbom et al. (1983) | 100 (15-55) | Ischemic | 40% |
| Hillbom et al. (1995) | 75 (16-40) | Ischemic | 28% |
| Barinagarrementeria et al. (1996) | 300 (<40) | Ischemic | 20% |
| Nayak et al. (1997) | 177 (15-45) | Ischemic | 22% |
| You et al. (1997) | 201 (15-55) | Ischemic | 59% |
| Ruiz-Sandoval et al. (1999) | 200(15-40) | Hemorrhagic | 9.5% |
| Kwon et al. (2000) | 149 (15-44) | Ischemic | 31.5% |
| Lee et al. (2002) | 264 (18-45) | Ischemic | 19.2% |
| Musolino et al. (2003) | 60 (17-45) | Ischemic 92%, TIA 8 % | 3.3% |
| Mehndiratta et al. (2004) | 127 (15-40) | Ischemic 85.5%, Hemorrhagic 14.5% | 2.3% |
| Lai et al. (2005) | 296 (15-45) | Hemorrhagic | 6.3% |
| Carod-Artal et al. (2005) | 130 (15-45) | Ischemic | 5.4% |
| Ruiz-Sandoval et al. (2006) | 35(18-40) | Hemorrhagic | 29% |
| Rasura et al. (2006) | 394(14-47) | Ischemic | 5% |
| Varona et al. (2007) | 272 (15-45) | Ischemic | 31% |
| Onwuchekwa et al. (2009) | 54 (18-45) | Ischemic 64.8%, Hemorrhagic 35.2% | 27.8% |
| Putaala et al. (2009a) | 1008 (15-49) | Ischemic | 14.2% |
| Bi et al. (2010) | 1988 (35-45) | Ischemic 94.3%, Hemorrhagic 5.7% | 38.2% |
| Spengos and Vemmos (2010) | 253 (≤45) | Ischemic | 13.8% |
| Balci et al. (2011) | 192 (18-47) | Ischemic | 9% |
| Patella et al. (2011) | 98 (14-45) | Ischemic | 0% |
| De Los Rios et al. (2012) | 501 (18-54) | Ischemic 69%, Hemorrhagic 22%, Unknown 9% | 15% |
| Von Sarnowski et al. (2013) | 4467 (18-55) | Ischemic, TIA | 33% |
| García-Rodríguez et al. (2013) | 1340 (20-89) | Hemorrhagic | 9.5% |
| Smajlovic et al. (2013) | 3864 (<45; ≥45) | Ischemic 79.9%, Hemorrhagic 20.1% | <45yr: 7.1%<br>≥45yr: 8.8% |
| Aarnio et al. (2014) | 970 (15-49) | Ischemic | 14.1% |
| Bugnicourt et al. (2014) | 104 (<60) | Ischemic, TIA | 11% |

| | | | |
|---|---|---|---|
| Chraa et al. (2014) | 128 (18-45) | Ischemic | 8% |
| Dash et al. (2014) | 440 (18-45) | Ischemic | 9.5% |
| Kalita et al. (2014) | 404 (16-50) | Hemorrhagic | 15.8% |
| Maaijwee et al. (2014) | 437 (18-50) | Ischemic | 6.4% |
| Renna et al. (2014) | 150 (<50) | Ischemic | 8.3% |
| Cruz-Herranz et al. (2015) | 102 (<45) | Ischemic 62.7%, TIA 23.5%, Hemorrhagic 2%, Unknown 11.8% | 2.1% |
| Maaijwee et al. (2015) | 511 (18-50) | Ischemic 63.7%, TIA 36.3% | 3.9% |

**Drug Use**

Stroke related to drug use is more common in younger patients compared to older patients (Bruno, 2003). Drug use has also been shown to be more common in males compared to females (Dash et al., 2014). Stroke risk related to drug use varies among young populations, although important variables are the patient's sex, type of drug, and amount taken. Petitti et al. (1998) found that catecholamine use in young women was associated with a 3.8 times greater risk for stroke. Bruno (2003) found young women using drugs containing phenylpropanolamine (PPA) were at a two-times higher risk of hemorrhagic stroke; appetite suppressants containing PPA increased hemorrhagic stroke risk by 16.6 times. However, PPA use among men is considerably lower and is not associated with increased risk of hemorrhagic stroke (Bruno, 2003).

Amphetamines, particularly methamphetamine, are a drug commonly associated with stroke. Amphetamines can trigger cardiovascular responses leading to hypertension, vasoconstriction, and focal myocyte necrosis, and have also been found to increase the risk of stroke by four times compared to non-users (Fonseca & Ferro, 2013). Westover et al. (2007) found amphetamine use to be associated with twice the risk of hemorrhagic stroke and mortality compared with cocaine use. In contrast, the authors found that amphetamine use did not increase the risk of ischemic stroke. Ecstasy (methylenedioxymethamphetamine) is a synthetic amphetamine derivative that has also been associated with young stroke (Fonseca & Ferro, 2013). Young patients who use ecstasy were found to have a lower cerebral blood vessel volume, which suggests that ecstasy related stroke may be caused by vasoconstriction (Bruno, 2003).

Cocaine use is a risk factor more unique to the young population. In patients with an absence of other known vascular risk factors, cocaine use is associated with at least 6.5 times higher risk of stroke (Broderick et al., 2003; Bruno, 2003; Petitti et al., 1998). Research concerning cocaine-induced stroke has demonstrated roughly equal proportions of ischemic and hemorrhagic events (Bruno, 2003). Potential mechanisms involved in cocaine-induced stroke include vasospasm, cerebral vasculitis, enhanced platelet aggregation, cardioembolism, and hypertensive surges associated with altered cerebral autoregulation and cerebral blood flow (Treadwell & Robinson, 2007). It has also been suggested that men are more commonly exposed to cocaine but women are more likely to become dependent (O'Brien, 1998). In a case control study conducted by Petitti et al. (1998), the authors found 4.7% of adolescent male cocaine users to be dependent, compared with 17.5% of female adolescents. However, there is no research as to whether this results in a higher mortality rate for cocaine-induced stroke in young women.

Another drug associated with young stroke is cannabis (marijuana). Westover et al. (2007) found a risk of 1.36 and 1.76 for cannabis use related to hemorrhagic and ischemic stroke, respectively. The authors found no variation with regard to race and drug-related stroke in young patients. In a study by Wolff et al. (2011), the authors found a highly significant association between cannabis use and multifocal

intracranial stenosis. Furthermore, the authors also observed a reversibility of vasoconstriction following cannabis withdrawal.

In a retrospective study, de Los Rios et al (2012) investigated the trend of substance abuse preceding stroke among young adults aged 18-54 years and found an alarming trend from 1993 to 2005. In 2005, 19.8% of young stroke patients admitted to illicit drug use compared to 3.8% in 1993-1994. The highest percentage of patients who had documented illicit drug use were those aged 35 years or younger, compared to those aged 35 to 54 years.

### Oral Contraceptives

The role of oral contraceptives (OC) relating to stroke has been controversial (Kristensen et al., 1997). When young female patients with ischemic stroke were compared to group-matched controls, OC use was found to be 11% higher in the young stroke population (Hillbom et al., 1995). Federico et al. (1990) found that 22% of young ischemic stroke patients were using OC, although the use of OC was considered as the probable cause of stroke in only one case. Likewise, Jiang et al. (2014) found OC use in 23% of 148 young women with stroke. A study by Camerlingo et al. (2000) found no OC-related stroke etiologies but considered it a risk factor for 26% of young patients. Similarly, Rasura et al. (2006) found no young OC-determined stroke etiologies, despite 38% of women using OC. Mehndiratta et al. (2004) found only 1 out of 109 patients with a cerebral infarction to have an OC-related etiology. In one study, the authors did not investigate the population for OC-related stroke etiologies, but found OC use in 77% of young women with stroke (Chraa et al., 2014).

The conflicting evidence of OC use and its association with stroke may be attributed to developments in OC and variations in doses. In a study of 295 young female patients post stroke, low-dose OC did not play a significant role in increasing stroke risk (Petitti et al., 1996). The strongest increase-of-risk relationship involving low-dose OC was when it was accompanied by smoking (Buring, 1996). In a meta-analysis of OC use in stroke, Roach et al. (2014) found that the risk of stroke in women with OC use was no different than in non-users. However, they found the risk of stroke to increase with OC dose, from an odds ratio of 0.6 for 20 μg to 3.2 for ≥50 μg. Overall, OC appears to play a minor role in young stroke etiology, but may be a risk factor particularly at high doses or when paired with other factors.

### Migraine

Migraine has been studied as both a risk factor and cause for young stroke. Schwaag et al. (2003) found migraine to be associated with a risk of 2.11 in young patients post stroke. Kristensen et al. (1997) found only 1 in 107 ischemic strokes to be migraine-induced, with 18% of men and 35% of women having a history of migraines. Federico et al. (1990) found similar results: 18% of young patients suffered from migraine, but migraine was considered a probable cause in only 2 of 45 recorded stroke events. Rasura et al. (2006) found migraine to be a risk factor for 26% of young stroke patients but to be the actual cause of stroke in none. In a larger study of 300 young patients with ischemic stroke, Barinagarrementeria et al. (1996) reported migraine to be the etiology in 10 patients (3%) and to be a risk factor in 27 patients (12%). These findings suggest that migraine is a common risk factor and an uncommon etiology.

Migraine as a risk factor tends to be more prevalent in females. MacClellan et al. (2007) studied 386 female patients aged 15-49 years after an ischemic stroke. Compared with 614 healthy female controls, no significant difference was found in prevalence of migraines between the groups. However, migraine with aura was found to be 9% higher in patients, with an associated stoke-risk increase of 1.5. Cruz-Herranz et al. (2015) found migraine as a risk factor in 25.3% of 102 young women, while von Sarnowski et al. (2013) found that 19% more females reported having a migraine than males. As well, Schwaag et

al. (2003) found no difference between patients and healthy age- and sex-matched controls with regard to migraine with aura, although the authors acknowledged migraine as a significant and independent risk factor for stroke in young women.

In a study by Von Sarnowski et al. (2013), migraines were found to be significantly more prevalent in patients aged 18-44 years compared to 45-55 years (29.7% vs. 24.4%). Camerlingo et al. (2010) found migraines to be associated with stroke in patients aged 16-44, although this association was not statistically significant in men. The greatest risk of stroke was to women who experienced migraine with aura, while migraine without aura was not significantly different between patients and healthy controls (Camerlingo et al., 2010). Similarly, Jiang et al. (2014) reported that 26.8% of young patients post stroke had migraine with aura compared to 6.4% who had migraine without aura. Moreover, Pezzini et al. (2011) found that young patients who experienced migraine with aura had a two-fold risk of ischemic stroke when compared with patients without migraine. The authors suggested, however, that migrainecan only be a risk factor when acting synergistically with other non-atherosclerotic factors.

### Hypertension

Hypertension (HTN) is common as both a cause and risk factor for stroke in young adults (Lai et al., 2005). As a risk factor, HTN has shown to be significantly associated with stroke in younger patients when compared to a healthy control population (Zhang et al., 2014). Within the young stroke population, males between the ages of 30 and 45 have the highest rate of HTN (Barinagarrementeria et al., 1996; Lai et al., 2005; Nayak et al., 1997; Varona et al., 2007), which is particularly true of males living in Asian populations (Lai et al., 2005; Lee et al., 2002; You et al., 1997). Unfortunately, young people may not be fully aware of the risks of hypertension or always be compliant with the provided treatment (Bi et al., 2010; Spengos & Vemmos, 2010).

**Table 21.3.1.3 Hypertension Prevalence in Young Stroke**

| Author, Year | Sample Size (Age Range) | Stroke Type | Prevalence of Risk Factor |
|---|---|---|---|
| Adams et al. (1986) | 144 (15-45) | Ischemic | 22% |
| Awada (1994) | 120 (15-45) | Hemorrhagic 41.5%, Ischemic 58.5% | 32% |
| Barinagarrementeria et al. (1996) | 300 (<40) | Ischemic | 7% |
| Nayak et al. (1997) | 177 (15-45) | Ischemic | 18% |
| You et al. (1997) | 201 (15-55) | Ischemic | 49% |
| Ruiz-Sandoval et al. (1999) | 200 (15-40) | Hemorrhagic | 13% |
| Camerlingo et al. (2000) | 135 (16-45) | Ischemic | 25.9% |
| Kwon et al. (2000) | 149 (15-44) | Ischemic | 38.3% |
| Lee et al. (2002) | 264 (18-45) | Ischemic | 45.8% |
| Musolino et al. (2003) | 60 (17-45) | Ischemic 92%, TIA 8 % | 21.7% |
| Schwaag et al. (2003) | 160 (15-45) | Ischemic 88.7%, TIA 11.3% | 28.8% |
| Mehndiratta et al. (2004) | 127 (15-40) | Ischemic 85.5%, Hemorrhagic 14.5% | 14.8% |
| Carod-Artal et al. (2005) | 130 (15-45) | Ischemic | 34.6% |
| Nedeltchev et al. (2005) | 203 (16-45) | Ischemic | 19% |
| Lai et al. (2005) | 296 (15-45) | Hemorrhagic | 48.7% |
| Panagiotakos et al. (2006) | 100 (<35) | Ischemic | 96% |
| Rasura et al. (2006) | 394 (14-47) | Ischemic | 23% |
| Lipska et al. (2007) | 214 (15-45) | Ischemic | 36% |
| Varona et al. (2007) | 272 (15-45) | Ischemic | 22% |
| Jovanović et al. (2008) | 865 (15-45) | Ischemic | 35% |

| | | | |
|---|---|---|---|
| Arnold et al. (2008) | 137 (< 45) | Ischemic | 19% |
| Onwuchekwa et al. (2009) | 54 (18-45) | Ischemic 64.8%, Hemorrhagic 35.2% | 77.8% |
| Putaala et al. (2009a) | 1008 (15-49) | Ischemic | 39.1% |
| De Silva et al. (2009) | 38 (15-45) | Ischemic | 21% |
| Samiullah et al. (2010) | 50 (15-35) | Ischemic 86%, Hemorrhagic 14% | 14% |
| Bi et al. (2010) | 1988 (35-45) | Ischemic 94.3%, Hemorrhagic 5.7% | 41.0% |
| Spengos and Vemmos (2010) | 253 (≤45) | Ischemic | 21.1% |
| Tan et al. (2010) | 67 (>50) | Ischemic | 65% |
| | 61 (>50) | Ischemic | 23% |
| Balci et al. (2011) | 192 (18-47) | Ischemic | 45% |
| Dharmasaroja et al. (2011) | 12 (15-30) | Ischemic, TIA | — |
| | 25 (31-40) | Ischemic, TIA | 24% |
| | 62 (41-50) | Ischemic, TIA | 36% |
| Fromm et al. (2011) | 100 (<50) | Ischemic | 27% |
| Janssen et al. (2011) | 94 (<50) | Ischemic 51%, TIA 49% | 56.4% |
| Patella et al. (2011) | 98 (14-45) | Ischemic | 34% |
| Chatzikonstantinou et al. (2012) | 104 (19-45) | Ischemic | 31.4% |
| Von Sarnowski et al. (2013) | 4467 (18-55) | Ischemic, TIA | 46.6% |
| Arntz et al. (2013)<br>Arntz et al. (2013)<br>Arntz et al. (2015) | 697 (18-50) | Ischemic 61%, TIA 29.6%,<br>Hemorrhagic 9.5% | 20.8% |
| Calviere et al. (2013) | 100 (16-55) | Ischemic | 18% |
| Dharmasarjoa et al. (2013) | 261 (≤60) | Ischemic | 49% |
| Eun et al. (2013) | 551 (40-64) | Ischemic | 57.9% |
| Giang et al. (2013) | 17149 (18-54) | Ischemic | 21.2% |
| Rolfs et al. (2013) | 3396 (18-55) | Ischemic 76%, TIA 16%,<br>Hemorrhagic 8%, Other 1.4% | 18-24yr: 10.7%<br>25-34yr: 14.1%<br>35-44yr: 36.9%<br>45-55yr: 58.8% |
| Smajlovic et al. (2013) | 3864 (<45; ≥45) | Ischemic 79.9%, Hemorrhagic 20.1% | <45yr: 44.8%<br>≥45yr: 75.4% |
| Tiamkao et al. (2013) | 85 (<45) | — | 8.2% |
| Aarnio et al. (2014) | 970 (15-49) | Ischemic | 39.1% |
| Béjot et al. (2014) | 4506 (<55) | — | 1985-1993: 46.3%<br>1994-2002: 34.5%<br>2003-2011: 36.6% |
| Bugnicourt et al. (2014) | 104 (<60) | Ischemic, TIA | 34% |
| Chen et al. (2014) | 568 (<65; 65-74;<br>≥75) | — | <65yr: 2.8%<br>65-74yr: 1.0%<br>≥75yr: 1.9% |
| Chraa et al. (2014) | 128 (18-45) | Ischemic | 49.2% |
| Dash et al. (2014) | 440 (18-45) | Ischemic | 44.5% |
| Jiang et al. (2014) | 397 (15-49) | Ischemic | 31.7% |
| Kalita et al. (2014) | 404 (16-50) | Hemorrhagic | 79.2% |
| Khealani et al. (2014) | 874 (16-45; >45) | Ischemic | 16-45yr: 37.9%<br>>45yr: 45.9% |
| Maaijwee et al. (2014) | 437 (18-50) | Ischemic | 52.8% |
| Palmcrantz et al. (2014) | 150 (18-64) | Ischemic 80%, Hemorrhagic 17%,<br>Other 3% | 46% |

| | | | |
|---|---|---|---|
| Park et al. (2014) | 25818 (15-45) | Ischemic | 18.0% |
| Renna et al. (2014) | 150 (<50) | Ischemic | 39.3% |
| Zhang et al. (2014) | 381 (18-45) | Ischemic | 46.6% |
| Bergman et al. (2015) | 2599 (15-44) | Ischemic 74.6%, Hemorrhagic 23.2%, Other 2.2% | 25.3% |
| Chiu et al. (2015) | 2063 (18-45) | Ischemic | 21.0% |
| Cruz-Herranz et al. (2015) | 102 (<45) | Ischemic 62.7%, TIA 23.5%, Hemorrhagic 2%, Other 11.8% | 10% |
| Koivunen et al. (2015) | 1257 (<50) | Hemorrhagic | 29.8% |
| Maaijwee et al. (2015) | 511 (18-50) | Ischemic 63.7%, TIA 36.3% | 53.2% |
| Man et al. (2015) | 105 (<55) | — | 20.8% |
| Park et al. (2015) | 4747 (18-90) | Ischemic | 20-45yr: 8.1%<br>45-65yr: 34.5%<br>≥66yr: 60.0% |
| Simonetti et al. (2015) | 624 (16-55) | Ischemic, Hemorrhagic | 16-45yr: 21%<br>46-55yr: 46% |
| Simonetti et al. (2015) | 249 (16-45) | Ischemic | 20% |
| González-Gómez et al. (2016) | 110 (<55) | Ischemic, Hemorrhagic | 50% |

## Hyperlipidemia

Hyperlipidemia and hypercholesterolemia are noted risk factors in the young stroke population (Zhang et al., 2014). These risk factors are suggested to be particularly prevalent among males aged 35-50 (Barinagarrementeria et al., 1996; Dharmasaroja et al., 2011; Rasura et al., 2006), although Carod-Artal et al. (2005) found hyperlipidemia to be 19% more common in patients over 50 years of age. Similar results were observed by Simonetti et al. (2015), who found that patients aged 46-55 years were 23% more likely to have hypercholesterolemia compared to patients aged 16-45 years. Chen et al. (2013) also found that patients over 65 years had a 9.9% greater prevalence of hypercholesterolemia compared to patients less than 65 years. When comparing the prevalence of hyperlipidemia in patients aged 18-55 years, Rolfs et al. (2013) found that patients 45-55 years had the highest rate of hyperlipidemia (41.3%).

In studies of young stroke, hyperlipidemia and hypercholesterolemia were consistently ranked as the fourth or fifth most common risk factor (Barinagarrementeria et al., 1996; Carod-Artal et al., 2005; Rasura et al., 2006; You et al., 1997). The exception is a study by Tan et al. (2002), which found hyperlipidemia to be the most common risk factor (80.7%) in patients aged 20-50. This finding may have been confounded by a generally high level of hyperlipidemia within the study population. Among controls, hyperlipidemia was also the highest risk factor, with a prevalence of 44.3%. Overall, hyperlipidemia and hypercholesterolemia are important risk factors for young stroke, with increasing prevalence and risk as the patients age.

**Table 21.3.1.4 Hyperlipidemia Prevalence in Young Stroke**

| Study | Sample Size (Age Range) | Stroke Type | Prevalence of Risk Factor |
|---|---|---|---|
| Barinagarrementeria et al. (1996) | 300 (<40) | Ischemic | 6% |
| You et al. (1997) | 201 (15-55) | Ischemic | 23% |
| Kwon et al. (2000) | 149 (15-44) | Ischemic | 8.1% |
| Lee et al. (2002) | 264 (18-45) | Ischemic | 53.1% |
| Schwaag et al. (2003) | 160 (15-45) | Ischemic 88.7%, TIA 11.3% | 30% |
| Carod-Artal et al. (2005) | 130 (15-45) | Ischemic | 11.5% |

| | | | |
|---|---|---|---|
| Nedeltchev et al. (2005) | 203 (16-45) | Ischemic | 39% |
| Lai et al. (2005) | 296 (15-45) | Hemorrhagic | 36.3% |
| Rasura et al. (2006) | 394(14-47) | Ischemic | 15% |
| Bi et al. (2010) | 1988 (35-45) | Ischemic 94.3%, Hemorrhagic 5.7%, | 4.2% |
| Balci et al. (2011) | 192 (18-47) | Ischemic | 35.4% |
| Dharmasaroja et al. (2011) | 12 (15-30) | Ischemic, TIA | 42% |
| | 25 (31-40) | Ischemic, TIA | 76% |
| | 62 (41-50) | Ischemic, TIA | 53% |
| Putaala et al. (2012) | 3944 (18-49) | Ischemic | 46% |
| Chatzikonstantinou et al. (2012) | 104 (19-45) | Ischemic | 27.6% |
| Von Sarnowski et al. (2013) | 4467 (18-55) | Ischemic, TIA | 34.9% |
| García-Rodríguez et al. (2013) | 1340 (20-89) | Hemorrhagic | 12.5% |
| Rolfs et al. (2013) | 3396 (18-55) | Ischemic 76%, TIA 16%, Hemorrhagic 8%, Other 1.4% | 18-24yr: 5.5%<br>25-34yr: 14.3%<br>35-44yr: 28.6%<br>45-55yr: 41.3% |
| Chraa et al. (2014) | 128 (18-45) | Ischemic | 7.8% |
| Dash et al. (2014) | 440 (18-45) | Ischemic | 7.8% |
| Zhang et al. (2014) | 381 (18-45) | Ischemic | 33.2% |
| Simonetti et al. (2015) | 249 (16-45) | Ischemic | 30% |

### Diabetes Mellitus

In patients under the age of 30, diabetes mellitus (DM) is not a notable risk factor for stroke (Mehndiratta et al., 2004). When compared with older patients, Awada et al. (1994) found DM to be 29% less common in patients under the age of 45. Ruiz-Sandoval et al. (2006) also found 16% fewer cases of DM in stroke patients younger than 40 years of age, while Smajlovic et al. (2013) found DM to be 20.6% more prevalent in patients older than 45 years. Khealani et al. (2014) reported a difference in DM of 9.4% in favour of patients older than 45 years relative to patients aged 16-45 years. Similarly, Simonetti et al. (2015) found that patients aged 46-55 years had a 10.5% greater prevalence of DM when compared to patients aged 16-45 years. It has also been reported that 13% of young stroke patients aged 30-40 had DM compared to 4.2% of patients aged 15-30 (Mehndiratta et al., 2004). This data suggests DM is a less common risk factor for young stroke patients.

**Table 21.3.1.5 Diabetes Mellitus Prevalence in Young Stroke**

| Author, Year | Sample Size (Age Range) | Stroke Type | Prevalence of Risk Factor |
|---|---|---|---|
| Arntz et al. (2013)<br>Arntz et al. (2013)<br>Arntz et al. (2015) | 697 | Ischemic 61%, TIA 29.6%, Hemorrhagic 9.5% | 5.7% |
| Calviere et al. (2013) | 100 (16-55) | Ischemic | 3% |
| Dharmasarjoa et al. (2013) | 261 (≤60) | Ischemic | 26% |
| Eun et al. (2013) | 551 (40-64) | Ischemic | 21.6% |
| García-Rodríguez et al. (2013) | 1340 (20-89) | Hemorrhagic | 3.1% |
| Giang et al. (2013) | 17149 (18-54) | Ischemic | 12.8% |
| Rolfs et al. (2013) | 3396 (18-55) | Ischemic 76%, TIA 16%, Hemorrhagic 8%, Other 1.4% | 18-24yr: 0.7%<br>25-34yr: 2.3%<br>35-44yr: 7.4%<br>45-55yr: 13.0% |
| Smajlovic et al. (2013) | 3864 (<45; ≥45) | Ischemic 79.9%, Hemorrhagic 20.1% | <45yr: 3.9% |

| | | | |
|---|---|---|---|
| | | | ≥45yr: 24.5% |
| Tiamkao et al. (2013) | 85 (<45) | — | 3.5% |
| Aarnio et al. (2014) | 970 (15-49) | Ischemic | 8.9% |
| Béjot et al. (2014) (2014) | 4506 (<55) | — | 1985-1993: 8.5%<br>1994-2002: 13.6%<br>2003-2011: 8.7% |
| Chen et al. (2014) | 568 (<65; 65-74; ≥75) | — | <65yr: 0.9%<br>65-74yr: 1.0%<br>≥75yr: 0.6% |
| Chraa et al. (2014) | 128 (18-45) | Ischemic | 13.2% |
| Dash et al. (2014) | 440 (18-45) | Ischemic | 13.9% |
| Jiang et al. (2014) | 397 (15-49) | Ischemic | 11.4% |
| Kalita et al. (2014) | 404 (16-50) | Hemorrhagic | 9.4% |
| Khealani et al. (2014) | 874 (16-45; >45) | Ischemic | 16-45yr: 8.6%<br>>45yr: 18.0% |
| Maaijwee et al. (2014) | 437 (18-50) | Ischemic | 11.4% |
| Zhang et al. (2014) | 381 (18-45) | Ischemic | 19.7% |
| Chiu et al. (2015) | 2063 (18-45) | Ischemic | 7.5% |
| Cruz-Herranz et al. (2015) | 102 (<45) | Ischemic 62.7%, TIA 23.5%,<br>Hemorrhagic 2%, Other 11.8% | 5.3% |
| Maaijwee et al. (2015) | 511 (18-50) | Ischemic 63.7%, TIA 36.3% | 12.1% |
| Man et al. (2015) | 105 (<55) | — | 6.9% |
| Park et al. (2015) | 4747 (18-90) | Ischemic | 20-45yr: 2.8%<br>45-65yr: 12.9%<br>≥66yr: 20.9% |
| Simonetti et al. (2015) | 624 (16-55) | Ischemic, Hemorrhagic | 16-45yr: 2.5%<br>46-55yr: 13% |
| Simonetti et al. (2015) | 249 (16-45) | Ischemic | 2% |
| González-Gómez et al. (2016) | 110 (<55) | Ischemic, Hemorrhagic | 18.2% |

**Plasma Homocysteine**

Elevated plasma homocysteine level has been found to increase risk of stroke. Bos et al. (2005) investigated the effect that plasma homocysteine level had on recurrent vascular events. They found a significant association between the risk of experiencing a recurrent vascular event and homocysteine level for patients following cerebral infarct or TIA. Tan et al. (2002) found hyperhomocysteinemia to be associated with cerebral infarction, independent of conventional risk factors. They reported that the risk of stroke may increase as a result of a proatherogenic effect, based on the association found between homocysteinemia and large-artery strokes.

In a retrospective review of young patients post stroke, Renna et al. (2014) found hyperhomocysteinemia to be present in 15.7% of the population. However, the authors found no significant differences when comparing patients based on sex or age group. Zhang et al. (2014) found high homocysteine to be significantly more prevalent in young patients post compared to healthy controls (41.3% vs. 21.5%; OR=2.1). The authors also compared individuals reported as dependent or independent in their activities of daily living at follow-up and found high homocysteine to be significantly more prevalent in dependent patients (57.5% vs. 34.5%; OR=2.2).

### Chlamydia Pneumonia

*Chlamydia pneumoniae*, a common etiologic agent in respiratory infections, has been suggested to have an association with stroke (Voorend et al., 2004). In a study conducted by Piechowski-Jozwiak et al. (2007), the authors found significant elevations of anti-*C. pneumoniae* antibodies in individuals with stroke compared to healthy individuals. They also found that a significantly greater proportion of individuals with stroke were seropositive to *C. pneumoniae* compared to healthy individuals. In contrast, a study conducted by Vorrend et al. (2004) found no mean difference in *C. pneumoniae* levels in young patients with atherosclerotic-determined stroke etiology and healthy controls. A large scale prospective study is necessary to confirm the validity of *C. pneumonia* as a risk for stroke in young patients (Anzini et al., 2004; Bandaru et al., 2009; Piechowski-Jozwiak et al., 2007; Voorend et al., 2004).

## 21.3.2 Summary

The most common risk factors for young stroke patients are modifiable (Broderick et al., 2003). Hypertension and smoking are consistently major risk factors for ischemic and hemorrhagic stroke in young populations (Awada, 1994; Mehndiratta et al., 2004; Varona et al., 2007; Waje-Andreassen et al., 2007). Uncommon and minor risk factors include migraine without aura, low-dose oral contraceptives, and *C. pneumonia* (Petitti et al., 1996; Piechowski-Jozwiak et al., 2007). Diabetes, hypercholesterolemia, hyperlipidemia, and elevated homocysteine levels are more prevalent post stroke in young patients aged 35-50 than those under 35 (Barinagarrementeria et al., 1996; Bos et al., 2005; Ruiz-Sandoval et al., 2006). Modifiable risk factors that tend to be unique to the young population include oral contraceptives, drug use, and cocaine use (Broderick et al., 2003; Bruno, 2003; Hillbom et al., 1995).

***Conclusions Regarding Modifiable Risk Factors***

***Smoking and hypertension are the most considerable risk factors for stroke in the young population.***

***Hyperlipidemia, diabetes mellitus, and elevated plasma homocysteine level are risk factors for stroke in the young population, particularly for those older than 35.***

***Drug use is an uncommon risk factor for stroke in general but is more common in the younger population.***

***Alcohol-related stroke events in the young population are relative to the amount consumed: one to two alcoholic beverages daily may reduce the risk of stroke, while excessive alcohol consumption can be a significant risk factor for stroke.***

***Migraine with aura is a risk factor for stroke in the young population, with young women at an elevated risk.***

***Oral contraceptives play minor role in risk of stroke in the young population when paired with other factors.***

***Further research is required to determine whether chlamydia pneumoniae is a risk factor for stroke in the young population.***

***Modifiable risk factors for stroke include smoking, hypertension, hyperlipidemia, diabetes mellitus, excessive alcohol consumption, and drug use, as well as oral contraceptive use and migraine with aura in women.***

### 21.3.3 Non-Modifiable Risk Factors

#### Sex

Studies report conflicting results regarding the incidence of stroke in young males and females, and which sex is more likely to experience stroke while young (Table 21.3.3.2). A report by Towfighi et al. (2011) found that women aged 35 to 64 years were more likely than men to report previous stroke. Similarly, Spengos and Vemmos (2010) found more women with stroke than men in the below 30 age group, while this pattern was reversed for those above the age of 30. As well, Putaala et al. (2012) also found that females with stroke outnumbered males with stroke in those aged <34 years, with a male to female ratio of 0.7. In patients aged >34 years, the male to female ratio linearly increased and reached 1.7 in patients aged 45-49 years.

In contrast, Smajlovic et al. (2013) found no significant difference in the proportion of women with stroke between those aged greater than and less than 45 years. It has been suggested that the large female population of very young stroke is due to the association that age and gender have with other risk factors such as oral contraceptive use and migraines (Carolei et al., 1993; Kwon et al., 2000). Despite these findings, other studies suggest that the female stroke population is decreasing (Naess et al., 2011).

While evidence for the association of stroke risk with the female sex is conflicting, studies show that the pathophysiology of stroke may differ between genders. For example, Martínez-Sánchez et al. (2011) found no difference in the sex of patients post stroke, but found that women experienced more severe strokes than men. Similarly, Dash et al. (2014) found cardioembolic strokes to be significantly more prevalent in young women (18.8% vs. 3%). The authors also observed a greater number of young women with multiple etiologies compared to men.

**Table 21.3.3.1 Sex Ratio in Young Stroke: Studies from 1983 to 2012**

| Author, Year | Sample Size (Age Range) | Stroke Type | Female : Male |
|---|---|---|---|
| Hillbom et al. (1983) | 100 (15-55) | Ischemic | 33 : 67 |
| Carolei et al. (1993) | 333 (15-44) | Ischemic | 48 : 52 |
| Awada et al. (1994) | 120 (15-45) | Ischemic 58.5%, Hemorrhagic 41.5% | 36.7 : 63.3 |
| Carolei et al. (1996) | 308 (15-44) | Ischemic | 47 : 53 |
| Rozenthul-Sorokin et al. (1996) | 253 (17-49) | Ischemic 80.6%, Hemorrhagic 17.8%, Other 1.6% | 37.2 : 62.8 |
| Kwon et al. (2000) | 149 (15-44) | Ischemic | 24.8 : 75.2 |
| Lee et al. (2002) | 264 (18-45) | Ischemic | 28.8 : 71.2 |
| Naess et al. (2002) | 23 (15-29) | Ischemic | 70 : 30 |
| | 209 (30-49) | | 62 : 38 |
| Jacobs et al. (2002) | 74 (20-45) | Hemorrhagic 55%, Ischemic 45% | 47 : 53 |
| Broderick et al. (2003) | 312 (18-49) | Hemorrhagic 100% | 61 : 39 |
| Musolino et al. (2003) | 60 (17-45) | Ischemic | 56.7 : 43.3 |
| Naess et al. (2004) | 232 (15-49) | Ischemic | 41 : 59 |
| Varona et al. (2004) | 272 (15-45) | Ischemic | 35 : 65 |
| Onwuchekwa et al. (2009) | 54 (18-45) | Ischemic 64.8%, Hemorrhagic 29.6%, Unclassified 5.6% | 51.9 : 48.1 |
| Putaala et al. (2009a) | 731 (15-49) | Ischemic | 37.2 : 62.8 |
| Bi et al. (2010) | 1988 (35-45) | Ischemic 94.3%, Hemorrhagic 5.7% | 27 : 73 |
| Camerlingo et al. (2010) | 314 (16-34) | Ischemic | 52.2 : 47.8 |
| Spengos and Vemmos (2010) | 253 (≤ 45) | Ischemic | 43.5 : 56.5 |
| Fromm et al. (2011) | 100 (< 50) | Ischemic | 28 : 72 |

| | | | |
|---|---|---|---|
| Kang et al. (2011) | 214 (45-54) | Ischemic 68%, Hemorrhagic 32% | 47 : 68 |
| Martínez-Sánchez et al. (2011) | 310 (≤ 50) | Ischemic | 41.3 : 58.7 |
| Naess et al. (2011) | 23 (16-30) | Ischemic | 69.6 : 31.4 |
| | 13 (16-30) | Ischemic | 0 : 100 |
| Zhang et al. (2011) | 669 (18-45) | Ischemic | 32.9 : 67.1 |
| Putaala et al. (2012) | 3944 (18-49) | Ischemic | 43.4 : 56.6 |

### Race

Race appears to be an important factor in the risk for stroke. Kittner et al. (1993) studied patients aged 15-44 years and found a significantly higher risk for cerebral infarction and intracerebral hemorrhage existed for young Black patients compared with young White patients. Similarly, Jacobs et al. (2002) found that the age-adjusted relative risk of any stroke was 2.4 times greater in Black versus White patients and 2.5 times greater in Hispanic versus White patients. Risk factor rates differ between races and can help explain the effect of race on stroke risk. Qureshi et al. (1995) studied all stroke inpatients between the ages of 15 and 94 over a 4.5 year period at an Atlanta hospital, of which 88% were Black. Hypertension was more commonly associated with stroke in Black patients than in non-Black patients (55% vs. 24%), with hypertensive intracerebral hemorrhage being the most common stroke type recorded among young Black patients (64%). Tsivgoulis et al. (2014) found hypertension and diabetes mellitus to be notably higher in Black patients compared to White and Asian patients. The authors also observed higher prevalence of hypercholesterolemia in Asian and White patients than Black patients.

### Previous Stroke

Previous stroke in young patients is an uncommon and poorly studied risk factor (Barinagarrementeria et al., 1996). In addition, studies have reported conflicting evidence regarding the proportion of young patients with previous stroke. Ruiz-Sandoval et al. (2006) found previous stroke to be 4% less common in young patients than in a matched population over 40 years of age. Khealani et al. (2014) also found previous stroke to be uncommon in young patients, with only 6.5% of patients aged 16-45 years reporting a previous stroke compared to 20.2% for patients older than 45 years. Conversely, Jovanović et al. (2008) found a history of stroke or transient ischemic attack in nearly a quarter (23%) of young patients.

Some studies have also shown that the prevalence of previous stroke in young patients increases with age. In a study of 3396 patients, Rolfs et al. (2013) found that 13.3% of patients aged 18-24 years had a previous stroke, which increased up to 20.7% for patients aged 45-55 years. Likewise, in a study of 4747 patients, Park et al. (2015) found previous stroke in 0.1% of patients aged 20-45 years compared to 1.9% in patients aged 45-65 years. However, Simonetti et al. (2015) found no significant difference in the proportion of patients with previous stroke in patients aged 16-45 years compared to those aged 46-55 years. Renna et al. (2014) also found no significant difference in previous stroke between patients greater than and less than 35 years.

**Table 21.3.3.2 Previous Stroke Prevalence in Young Stroke**

| Author, Year | Sample Size (Age Range) | Stroke Type | Prevalence of Risk Factor |
|---|---|---|---|
| Adams et al. (1986) | 144 (15-45) | Ischemic | 14%* |
| Awada (1994) | 120 (15-45) | Hemorrhagic 41.5%, Ischemic 58.5% | 6% |
| Barinagarrementeria et al. (1996) | 300 (<40) | Ischemic | 11.7% |
| Nayak et al. (1997) | 177 (15-45) | Ischemic | 13% |
| Lee et al. (2002) | 264 (18-45) | Ischemic | 21. 7% |
| Carod-Artal et al. (2005) | 130 (15-45) | Ischemic | 7.7% |

| | | | |
|---|---|---|---|
| Ruiz-Sandoval et al. (2006) | 35 (18-40) | Hemorrhagic | 9% |
| Jovanović et al. (2008) | 865 (15-45) | Ischemic | 23% |
| Bi et al. (2010) | 1988 (35-45) | Hemorrhagic 95.7%, Ischemic 94.3% | 14.9% |
| Fromm et al. (2011) | 100 (<50) | Ischemic | 4% |
| Chen et al. (2013) | 973 (<65; ≥65) | Ischemic | <65yr: 47.3%<br>≥65yr: 58.0% |
| Dharmasaroja et al. (2013) | 261 (≤60) | Ischemic | 13% |
| Eun et al. (2013) | 551 (>40) | Ischemic | 3.0% |
| Giang et al. (2013) | 17149 (18-54) | Ischemic | 3.8% |
| Rolfs et al. (2013) | 3396 (18-55) | Ischemic 76%, Hemorrhagic 8%, TIA 16%, Other 1.4% | 18-24yr: 13.3%<br>25-34yr: 14.0%<br>35-44yr: 17.3%<br>45-55yr: 20.7% |
| Dash et al. (2014) | 440 (18-45) | Ischemic | 26% |
| García-Rodríguez et al. (2013) | 1340 (20-89) | Hemorrhagic | 8.3% |
| Jiang et al. (2014) | 397 (15-49) | Ischemic | 5.1% |
| Khealani et al. (2014) | 874 (>14) | Ischemic | 16-45yr: 6.5%<br>>45yr: 20.2% |
| Palmcrantz et al. (2014) | 150 (18-64) | Ischemic 80%, Hemorrhagic 17%, Unspecified 3% | 17% |
| Park et al. (2015) | 4747 (18-90) | Ischemic | 20-45yr: 0.1%<br>45-65yr: 1.9%<br>≥66yr: 6.0% |
| Simonetti et al. (2015) | 624 (16-55) | Ischemic, Hemorrhagic | 16-45yr: 13%<br>46-55yr: 14% |
| Simonetti et al. (2015) | 154 (16-45) | Ischemic | 3% |

*Transient ischemic attacks only

### Family History of Stroke

Family history of stroke as a risk factor for young patients requires further research (Schwaag et al., 2003). The small amount of available data appears conflicting and inconclusive. Mehndiratta et al. (2004) found family history of stroke to be present in only 2.7% of young ischemic stroke patients. In contrast, Rasura et al. (2006) and Patella (2011) found it to be a common risk factor present in 63% and 74.5% of young patients, respectively. In a case control study, family history of vascular events was similar in both young patients post stroke and a group of age- and gender-matched controls (Schwaag et al., 2003). The odds of having a family history of subarachnoid haemorrhage for patients 15-49 years of age was 1.92, which was not significantly different between age groups (Bor et al., 2008). In a study conducted by Högström et al. (2015), the authors found maternal history of stroke to be significantly associated with ischemic stroke, while family history of stroke was not a significant risk factor for hemorrhagic stroke. The authors also found that significantly younger patients had a parental history of stroke when compared to healthy controls.

Recent studies have found the percentage of young patients with a family history of stroke to range from 9.4% to 35.4% (Aarnio et al., 2014; Dash et al., 2014; Goeggel Simonetti et al., 2015; Kalita et al., 2014; Zhang et al., 2014). Differences between studies may be due to the varying definitions of 'family history' used. For example, Lai et al. (2005) used a family history of stroke if "patients had no obvious risk factors", whereas Rasura et al. (2006) and Patella et al. (2011) were more specific, listing family history as a "history of cardio- and cerebrovascular disease in first degree relatives". Studies have also suggested that family history of stroke may be a more significant risk factor in older participants. In a

study conducted by Rolfs et al. (2013), the authors found family history of stroke to increase in prevalence with age, from 26.2% in patients aged 18-24 years to 43.0% in patients aged 45=55 years. Similarly, Simonetti et al. (2015) found 18% of patients aged 16-45 years to have a family history of stroke compared to 30% of patients aged 46-55 years.

**Table 21.3.3.3 Family History of Stroke Prevalence in Young Stroke**

| Author, Year | Sample Size (Age Range) | Stroke Type | Prevalence of Risk Factor |
|---|---|---|---|
| Nayak et al. (1997) | 177 (15-45) | Ischemic | 6% |
| Lee et al. (2002) | 264 (18-45) | Ischemic | 29.3% |
| Mehndiratta et al. (2004) | 127 (15-40) | Hemorrhagic 14.5%, Ischemic 85.5% | 2.7% |
| Schwaag et al. (2003) | 160 (15-45) | Ischemic 88.7%, TIA 11.3% | 15% |
| Lai et al. (2005) | 296 (15-45) | Hemorrhagic | 6.7% |
| Rasura et al. (2006) | 394 (14-47) | Ischemic | 63% |
| Jovanović et al. (2008) | 865 (15-45) | Ischemic | 9% |
| De Silva et al. (2009) | 38 (15-45) | Ischemic | 18% |
| Spengos and Vemmos (2010) | 253 (≤45) | Ischemic | 12.6% |
| Balci et al. (2011) | 192 (18-47) | Ischemic | 18% |
| Janssen et al. (2011) | 90 (<50) | Ischemic 51%, TIA 49% | 44.4% |
| Patella et al. (2011) | 98 (14-45) | Ischemic | 74.5% |
| Rolfs et al. (2013) | 3396 (18-55) | Ischemic 76%, Hemorrhagic 8%, TIA 16%, Other 1.4% | 18-24yr: 26.2%<br>25-34yr: 35.9%<br>35-44yr: 40.2%<br>45-55yr: 43.0% |
| Aarnio et al. (2014) | 970 (15-49) | Ischemic | 13.1% |
| Dash et al. (2014) | 440 (18-45) | Ischemic | 15.7% |
| Kalita et al. (2014) | 404 (16-50) | Hemorrhagic | 9.4% |
| Zhang et al. (2014) | 381 (18-45) | Ischemic | 35.4% |
| Simonetti et al. (2015) | 624 (16-55) | Ischemic, Hemorrhagic | 16-45yr: 18%<br>46-55yr: 30% |
| Simonetti et al. (2015) | 249 (16-45) | Ischemic | 17% |
| Thijs et al. (2015) | 4232 (<55) | Ischemic, TIA | 37.3% |
| Ilinca et al. (2016) | 426 (<55) | Ischemic, TIA | 13% |

## Atrial Fibrillation

Atrial fibrillation, the most common cardiac arrhythmia, is present in approximately 0.4% of the general population (Mattle et al., 2003). It has been shown to potentially lead to stroke through thrombus formation and subsequent fragmentation (Aggarwal et al., 2015). However, there is little evidence for atrial fibrillation as a risk factor for stroke in young adults. Studies have reported the percentage of young patients with atrial fibrillation to range from 1.7% to 10.6% (Arntz et al., 2015; Tiamkao et al., 2013). Further study is required to discern if atrial fibrillation is a significant risk factor for stroke in young adults.

**Table 21.3.3.4 Atrial Fibrillation Prevalence in Young Stroke: Studies from 2013 to 2015**

| Author, Year | Sample Size (Age Range) | Stroke Type | Prevalence of Risk Factor |
|---|---|---|---|
| Arntz et al. (2013)<br>Arntz et al. (2013)<br>Arntz et al. (2015) | 697 (18-50) | Ischemic 61%, TIA 29.6%, Hemorrhagic 9.5% | 1.7% |

| | | | |
|---|---|---|---|
| Chen et al. (2013) | 973 (20-64; 65-98) | Ischemic | <65yr: 8.2%<br>≥65yr: 24.1% |
| Dharmasarjoa et al. (2013) | 261 (≤60) | Ischemic | 17% |
| Eun et al. (2013) | 551 (40-64) | Ischemic | 6.4% |
| García-Rodríguez et al. (2013) | 1340 (20-89) | Hemorrhagic | 4.3% |
| Giang et al. (2013) | 17149 (18-54) | Ischemic | 3.4% |
| Smajlovic et al. (2013) | 3864 (<45; ≥45) | Ischemic 79.9%, Hemorrhagic 20.1% | <45yr: 1.3%<br>≥45yr: 16.1% |
| Tiamkao et al. (2013) | 85 (<45) | — | 10.6% |
| Aarnio et al. (2014) | 970 (15-49) | Ischemic | 4.0% |
| Béjot et al. (2014) | 4506 (<55) | — | 1985-1993: 2.4%<br>1994-2002: 3.6%<br>2003-2011: 3.8% |
| Bugnicourt et al. (2014) | 104 (<60) | Ischemic, TIA | 5% |
| Dash et al. (2014) | 440 (18-45) | Ischemic | 6.6% |
| Khealani et al. (2014) | 874 (16-45; >45) | Ischemic | 16-45yr: 4.3%<br>>45yr: 6.2% |
| Bergman et al. (2015) | 2599 (15-44) | Ischemic 74.6%, Hemorrhagic 23.2%, Unspecified 2.2% | 2.8% |
| Simonetti et al. (2015) | 624 (16-55) | Ischemic, Hemorrhagic | 16-45yr: 1.8%<br>46-55yr: 5% |

## Mitral Valve Prolapse

Mitral valve prolapse (MVP) occurs in approximately 3-6% of the young adult population (Adams et al., 1986; Gilon et al., 1999). Among young stroke patients, MVP is considered a minimal risk factor and an infrequent sole etiology (Adams et al., 1986; Bevan et al., 1990; Gilon et al., 1999; Mehndiratta et al., 2004). In contrast, Bogousslavsky and Regli (1987) conducted a study with 41 patients under the age of 40 and reported that 30% had MVP stroke etiology. The authors attributed this finding to the use of echocardiography during assessment, although echocardiography has been used by several researchers who did not find similar results (Adams et al., 1986; Bevan et al., 1990; Gilon et al., 1999; Mehndiratta et al., 2004). In a study of 85 young patients with stroke, Tiamkao et al. (2013) found 6.4% of males to have MVP compared to 15.8% of females. Reported discrepancies in MVP prevalence may be due to changing diagnostic criteria or a range of risk factors accompanying the MVP (Gilon et al., 1999).

## Patent Foramen Ovale

Patent foramen ovale (PFO) or PFO with atrial septal aneurysm (ASA) is a relatively common cardiac abnormality (Guercini et al., 2008). In young patients, particularly those with cryptogenic etiology, PFO has been found with increased frequency (Cramer, 2005). Larrue et al. (2011) investigated the etiology of stroke in patients aged 16-54 years and found PFO+ASA to be the most prevalent uncertain cause of stroke in 43 of 318 patients (13.5%). The authors noted that this rate was generally greater than in previous studies, but they suggested that previous studies had underestimated the prevalence of PFO. In a meta-analysis by Piechowski-Jozwiak and Bogousslavsky (2013), PFO (OR=3.10) and PFO+ASA (OR=15.59) were found to be significantly associated with ischemic stroke in patients under the age of 55. However, despite the high rates of PFO in young patients with cryptogenic stroke, the exact role of PFO in stroke pathogenesis is unknown, which complicates secondary stroke prevention in young patients with a PFO (Cramer, 2005). Rodés-Cabau et al. (2009) performed a prospective study for patients under the age of 55 that had been diagnosed with cryptogenic stroke, and found that patients with PFO had lower atherosclerotic burden when compared to those without PFO. The authors

concluded that an atherosclerotic-mediated mechanism is not likely to be involved in stroke that occurs in the presence of PFO.

### Pregnancy and Postpartum Stroke

There have been no definitive studies evaluating the incidence and types of pregnancy-related stroke, but there have been retrospective studies that have attempted to determine trends in incidence, etiology, risk factors, and prognosis (Davie & O'Brien, 2008; Feske, 2007) (see Table 21.3.3.5). In general, the approximate incidence of pregnancy-related stroke ranges between 4 and 34 per 100,000 (Davie & O'Brien, 2008; Egido & Alonso de, 2007). Studies have also shown that approximately 90% of the strokes occur in the last trimester, and are twice as likely to occur in women over the age of 35 (Davie & O'Brien, 2008; Egido & Alonso de, 2007; Feske, 2007; Pathan & Kittner, 2003). In one study conducted by Lamy et al. (2000), the risk of stroke postpartum was shown to be higher than during any trimester (RR=2.2). As well, the estimated mortality rate following pregnancy-related stroke ranges from 10-17.8% (Davie & O'Brien, 2008; Feske, 2007).

**Table 21.3.3.5 Studies included in Feske (2007) and Davie & O'Brien (2008)**

| Retrospective Studies | Inpatient Registries |
|---|---|
| Wiebers and Whisnat (1985) | Roset al. (2001) |
| Sharsharet al. (1995) | Jenget al. (2004) |
| Awadaet al. (1995) | James et al. (2005) |
| Kittneret al. (1996) | Ling et al. (2006) |
| Witlinet al. (1997) | |
| Lanskaet al. (2000) | |
| Jaigobin and Silver (2000) | |

Risk factors for stroke during pregnancy or postpartum include hypertension, diabetes, thrombophilia, anemia, sickle cell disease, smoking, alcohol/substance abuse, increased gestational age, increased maternal age, strenuous labour, multiparity, caesarean section, pre-eclampsia, eclampsia, and aneurysmal rupture (Davie & O'Brien, 2008; Feske, 2007; James et al., 2005). In particular, pre-eclampsia or eclampsia was found in 25-45% of pregnant patients (Davie & O'Brien, 2008; Feske, 2007). Feske (2007) found patients with a history of pre-eclampsia to have up to a 60% greater risk of recurring stroke outside of pregnancy. A systematic review by Tate and Bushnell (2011) found intracerebral hemorrhages to be caused by pre-eclampsia and eclampsia in 8%-44% of cases. In addition, Kajantie et al. (2009) found that the offspring of women who had pre-eclampsia were more likely to have a stroke than those born to normotensive mothers. Recurrent stroke tends to occur during pregnancy in about 1-2% of patients (Pathan & Kittner, 2003).

## 21.3.4 Summary

Young populations have both conventional and unique non-modifiable risk factors for stroke (Ning & Furie, 2004). The most prominent non-modifiable risk factors for young stroke are sex, race, and family history of stroke. Evidence for sex as a significant risk factor for young stroke is inconclusive, despite reports that more women tend to suffer stroke at a young age compared to men (Putaala et al., 2012; Spengos & Vemmos, 2010). Race also appears to play a significant role in stroke risk, which is particularly true of hypertensive stroke in Black patients (Kittner et al., 1993). Although the data regarding family history is conflicting, some studies have found it to significantly influence stroke risk in young adults (Lee et al., 2002; Rasura et al., 2006; Schwaag et al., 2003). Family history of stroke also tends to be more significant in older participants (Goeggel Simonetti et al., 2015; Rolfs et al., 2013).

Another risk factor thought to be associated with young stroke is patent foramen ovale, especially for stroke with cryptogenic etiology (Piechowski-Jozwiak & Bogousslavsky, 2013). Mitral valve prolapse, atrial fibrillation, and previous stroke are all uncommon risk factors not strongly associated with stroke in young patients. A unique non-modifiable risk factor for young female populations is pregnancy and postpartum. Stroke during these periods is uncommon, and usually attributed to pre-eclampsia or eclampsia (Feske, 2007).

***Conclusions Regarding Non-Modifiable Risk Factors***

***Previous stroke in young patients is less common than in older patients.***

***Sex appears to be related to age at stroke onset, with young patients under the age of 35 more likely to be female and above the age of 35 more likely to be male.***

***Race appears to be an important risk factor for stroke in young populations, with elevated risk for young Black patients.***

***Atrial fibrillation appears to be an uncommon and understudied risk factor for stroke in young patients.***

***Mitral valve prolapse appears to be a minimal risk factor and infrequent sole etiology for stroke in young patients.***

***The significance of family history of stroke and patent foramen ovale as risk factors for stroke in young patients is unclear.***

***Pregnancy and postpartum state are unique periods of elevated stroke risk in young female patients.***

***Non-modifiable risk factors for stroke include sex, race, previous stroke, family history of stroke, atrial fibrillation, mitral valve prolapse, patent foramen ovale, and pregnancy/postpartum in young females.***

## 21.4 Recovery and Prognosis

It is well known that young patients demonstrate greater neurological and functional recovery following stroke, and thus have a better prognosis, when compared to older patients (Adunsky et al., 1992; Hindfelt & Nilsson, 1977; Marini et al., 2001; Nedeltchev et al., 2005). However, a substantial number of young individuals are forced to cope with permanent neurological deficits over a decade after their stroke (Schaapsmeerders et al., 2013). Compared to age-matched controls who have not experienced a stroke, young were found to have a worse prognosis regarding memory, anxiety, and depression despite seemingly excellent functional outcomes (Waje-Andreassen et al., 2013). Data is not entirely conclusive in determining the relationship between subtype/severity of stroke and level of improvement (Black-Schaffer & Winston, 2004). However, Vibo et al. (2012) found that increasing age (45-54 vs. 0-44) and hemorrhagic stroke were associated with lower long-term survival rates.

In general, older age is associated with poorer rehabilitation outcomes (Nedeltchev et al., 2005), particularly for the oldest patients (Falconer et al., 1994). In a review of 979 patients with ischemic or hemorrhagic stroke, a negative relationship was found between age and functional independence score during hospital stay (Black-Schaffer & Winston, 2004). As well, younger patients with greater functional independence were also 30% more likely to return home. Younger patients' hospital stays were an average of 23 days longer than older patients, although this may be due to the increased likelihood of older patients being discharged directly to nursing homes (Black-Schaffer & Winston, 2004; Falconer et al., 1994). Some research has shown that young patients benefit more from intravenous tPA post stroke compared to older patients (Poppe et al., 2009; Toni et al., 2012). However, the lack of significant

medical comorbidities may cause younger patients to fare better than older patients (Poppe et al., 2009).

A study by Knoflach et al. (2012) found age to negatively predict good functional outcome according to the Modified Rankin Scale (mRS). The authors observed that the probability of a good outcome decreased by 3.1-4.2% for each 10 year increase in age up to 75 years of age; the probability of a good outcome was found to decrease by 10% for every 10 year increment after 75. These findings are supported by Kato et al. (2015), who reported that the younger stroke population had higher scores for functional ability measured by the mRS and less severe stroke when compared to the older population. Contrary to these findings, in a comparison of mRS scores at discharge, Khealani et al. (2014) found no difference in the proportion of poor functional outcome between patients older or younger than 45 years. Despite this, strong evidence suggests that young adults with stroke experience a greater functional recovery when compared to older adults (Black-Schaffer & Winston, 2004; Dharmasaroja et al., 2013; Ferro & Crespo, 1988; Kuptniratsaikul et al., 2013; Park et al., 2014; Waje-Andreassen et al., 2013).

Younger patients are also more likely to have a better long-term survival rate (Nedeltchev et al., 2005). In a retrospective study of patients that had died as a result of cerebral stroke from 2000 to 2010, Martirosyan and Krupskaya (2013) found that patients younger than 45 years of age accounted for only 3.0% of deaths, compared to 17.6% for patients aged 45 to 59 years and 47.6% for patients aged 60 to 74 years. The authors also found that the mortality rate in patients less than 45 years decreased from 5.3% in 2000 to 2.1% in 2010, while the mortality rate in patients aged 45 to 59 years decreased from 21.1% to 12.4%. Similarly, Smajlovic et al (2013) studied 3864 young adults post stroke from 2001 to 2005, and found mortality to be 19% lower in young adults than older adults. Prospectively, Rutten-Jacobs et al. (2013a) calculated the 20 year cumulative mortality rate for stroke patients and found a significant difference between groups, with the lowest rate in patients 18 to 29 years of age (18-29: 10.2%; 30-39: 23.9%; 40-50: 32.9%). While studies generally report lower mortality rates with young stroke compared to older stroke, it is important to note that these results are mostly crude rates and do not reveal the excess mortality associated with young stroke (Rutten-Jacobs et al., 2013a). Differences in mortality may be attributed to differences in other factors such as socioeconomic status and race (Lindmark et al., 2014; Tsivgoulis et al., 2014).

Long-term follow-up of young patients post stroke has also indicated that young stroke may be associated with impaired cognition and recurrent stroke (Waje-Andreassen et al., 2013). In a prospective study assessing post-stroke cognition in young patients relative to healthy controls, Maaijwee et al. (2014) found both subjective and executive memory failures to be significantly more prevalent in the young patients. Similar results were observed in a study by Schaapsmeerders et al. (2013) of cognitive performance in young patients post stroke. Studies have also suggested that young patients may be at a higher risk of recurrent stroke, with the reported incidence rate ranging from 0.7% to 19.2% (Bogousslavsky & Regli, 1987; Eun et al., 2013). However, Rutten-Jacobs et al. (2013a) found no significant difference in the risk of recurrent stroke between age groups.

***Conclusions Regarding Recovery and Prognosis for Younger Patients Post Stroke***

***Young patients have better neurological recovery, less functional disability, and greater long-term survival post stroke than older patients.***

***Impaired cognitive performance and recurrent stroke may be associated with post-stroke recovery in young patients.***

***Young patients have better recovery and prognosis compared to older patients following stroke.***

## 21.5 Rehabilitation

Traditional rehabilitation is generally the same for younger and older stroke patients (Teasell et al., 2000). The major difference between the rehabilitation of the two groups lies in the differing nature of neurological recovery and associated social issues. The nature of family supports, presence of young dependents, marital stress, and return to work are all issues generally associated with younger stroke rehabilitation (Dixon et al., 2007). Further, stroke rehabilitation for younger individuals should emphasize participation in fitness activities (i.e. high-demand leisure activities), as these are often the activities given up following a stroke (Wolf et al., 2012). Common rehabilitation regimes include some combination of physiotherapy, occupational therapy, speech language therapy, and pharmacological therapy (Stein, 2004; Young & Forster, 2007). Strategies to improve motor recovery in young patients include: constraint-induced movement therapy, robot-aided rehabilitation, virtual reality training, functional electrical stimulation, increased exercise intensity, and acupuncture (Stein, 2004). For detailed information on stroke-specific rehabilitation, see Chapter 6: The Elements of Stroke Rehabilitation.

A major difference in the stroke rehabilitation of young patients is that, on average, they will have longer to live with residual disability (O'Connor et al., 2005). Without appropriate rehabilitation, this longer period of time with disability can result in large dependency costs. O'Connor et al. (2011) looked at the economic benefit of rehabilitation for working age adults and found that it would require 21 weeks of inpatient rehabilitation in order for the rehabilitation to offset the cost of dependency. Additionally, young patients will likely have seen less natural age-related deterioration of their cognitive and physical functions. Terént et al. (2009) found that young patients receive greater relative benefits from stroke unit care than elderly patients. For information on age-related rehabilitation outcomes, see Chapter 4: Managing the Stroke Rehabilitation Triage Process.

### 21.5.1 Perceptions of Care

Young patients often come from a different life situation than older patients following stroke (Stone, 2005). Their needs may be different and this may affect their outlook on the rehabilitation process (Dixon et al., 2007). In a study of young adults with neurological disability, Dixon et al. (2007) found patients had established two perspectives on rehabilitation: 'Recovery' and 'Adaptation' (see Table 21.5.1.1).

**Table 21.5.1.1 Patient Perspectives on Rehabilitation** (Dixon et al., 2007)

| **Recovery Model (33% of participants)** |
|---|
| • More common early in rehabilitation process<br>• Unrelated to duration of impairment<br>• May be due to unfamiliarity and uncertainty with environment<br>• May cause difficulties in psychological adjustment to living with neurological impairments<br>• Patients may lack willingness to participate in adaptive behaviours |
| **Adaptation Model (42% of participants)** |
| • More consistent with professionals' aims for rehabilitation<br>• May require time to adjust to this approach<br>• Patients recognize value of rehabilitation despite underlying impairment |
| *The remaining 25% of participants subscribes to both models* |

The recovery model defines rehabilitation as a process for patients to return to their pre-morbid state, whereas the adaptation model defines rehabilitation as a transitional adaptation and making the most of the patient's abilities (Dixon et al., 2007). Hartke and Brashler (1994) reported on a questionnaire administered to 100 young patients post stroke, pertaining to the programs they felt would be most helpful during inpatient rehabilitation. Although regarded as generally important, patients rated exercise/fitness programs as far more important than rated by physicians, while physicians prioritized sexual adjustment counselling more than patients (Hartke & Brashler, 1994). Patients have also expressed the need for more information following stroke as essential, specifically about the disease and their prognosis (Dixon et al., 2007; Low et al., 2003; Röding et al., 2003). The patients sensed that people had trouble comprehending them, and had concerns about others perception of their constant fatigue (Stone, 2007).

According to Hartke and Brashler (1994), "The *programs most frequently valued did not necessarily parallel development issues prescribed to be pertinent to a younger age group. Only vocational counselling was frequently chosen as valuable among the high-functioning survivors. Interventions concerning sexual functioning, parenting, and dating/interpersonal relationships were chosen relatively less frequently, although they might be assumed to be developmentally salient at a younger age*". The same authors noted that, "*In comparing the high- and low-functioning respondents, it is not surprising to observe the high-functioning survivors more frequently valuing vocational counselling and low-functioning survivors ranking family counselling higher. The high-functioning subgroup might be in pursuit of ambitions to return to work. In contrast, the low-functioning subgroups may have been expressing greater concern over family strain due to their dependence*" (Hartke & Brashler, 1994).

While stroke rehabilitation offered to young patients is similar to that of older patients, younger patients present many unique issues after stroke (Teasell et al., 2000). Their life situation and neurological recovery are often different than that of older patients. Consideration should be given to their unique struggle, with a greater focus on psychosocial issues (Teasell et al., 2000). This concept is supported by a study conducted by Röding et al. (2003), which noted that medical doctors and rehabilitation therapists often ignore cognitive deficits in young patients and instead focus on regaining functional ability. Helpful interventions for young patients post stroke may involve the development of active strategies, cognitive behavioural therapy, and the involvement of social supports (Ch'Ng et al., 2008). Furthermore, studies have noted that almost half of young patients are diagnosed with some degree of post-stroke depression (Kappelle et al., 1994; Neau et al., 1998), which is associated with a poor outcome following rehabilitation (Neau et al., 1998).

Advanced understanding of cognitive deficits is required for a more effective rehabilitation program (Röding et al., 2003). Röding et al. (2003) also reported young patients' desire for age-adapted stroke rehabilitation programs, including a need for communication with other patients their age that had been affected by similar experiences. In an attempt to address these needs, Muller et al. (2014) enrolled 13 young patients in a social support program designed to facilitate role attainment and socialization post stroke. Although the authors found little improvement on the Stroke Impact Scale, they found significant improvement on the Community Integration Questionnaire and strong positive responses associated with the program on the post-participation survey. Overall, however, younger patients appear to be pleased with traditional stroke rehabilitation programs (Dixon et al., 2007; Kappelle et al., 1994).

***Conclusions Regarding the Rehabilitation of Younger Patients Post Stroke***

***Rehabilitation of young patients post stroke is similar to that of older patients, with the main differences being the nature of neurological recovery and associated social issues.***

***Stroke rehabilitation programs with an emphasis on socialization and community integration could be effective for young patients.***

***Stroke rehabilitation of younger patients differs from the more traditional rehabilitation of older patients because of better likelihood of neurological recovery and unique social issues for younger patients.***

## 21.6 Family Stress

Stroke can affect all members of a family system. In particular, spouses, children, and parents of patients often have to make large adjustments to deal with their relative's disability (Visser-Meily et al., 2005b). With younger patients, it can be anticipated that the need for a caregiver is be less given their tendency to make a more complete neurological and functional recovery (Hindfelt & Nilsson, 1992). However, whether or not a fulltime caregiver is necessary, other family members often assume new responsibilities to cope with the disability of their relative post stroke (Teasell et al., 2000). Apart from the primary caregiver, other family members generally play only minor roles (Horowitz, 1985; Tobin & Kulys, 1981). Primary caregivers for younger patients may also be more readily available, as spouses or parents are more likely to be alive, local, and able to assist. For more information, see Chapter 19: Community Reintegration.

Buschenfeld et al. (2009) found that caregivers could be both positively and negatively impacted by a partner's stroke. Although caregivers reported changes in their self-identity and a lack of intimacy and familiarity in their relationship, they found adjustment had to occur and coped by managing emotions, drawing from previous experiences, comparing themselves to others, and depending on social support (Buschenfeld et al., 2009). In a study comparing experiences of young individuals and their partners after stroke, Banks and Pearson (2004) found that both patients and caregivers experience stress at the initial crisis, treatment and realization, as well as adjustment stages, but they experience different types of stress at each of these stages (see Table 21.6.1).

**Table 21.6.1 Stress Sources for Patient and Partner** (Banks & Pearson, 2004)

| Stage | Patient | Partner |
|---|---|---|
| Initial Crisis | • Stroke event, seeking assistance | • Stroke event, seeking assistance, or receiving bad news |
| Treatment & Realization | • Admission to hospital<br>• Inpatient stay<br>• Coming home<br>• Coping with change | • Coping with crisis<br>• Hospital visits<br>• Homecoming |
| Adjustment | • Impact on relationships | • Impact on relationships |

Family members providing care for stroke survivors face their own adjustment problems, as their personal needs are often sacrificed to meet the needs of the individual receiving care. Visser-Meily et al. (2005b) found a correlation between the amount of strain and the level of depression in spouses of younger patients post stroke; partner strain was often due to emotional distress in children having difficulty coping. The same authors found levels of spousal depression and quality of marital relationship one year post stroke to be relative to their originally measured levels. Teasell et al. (2000) found 38% of young patients experienced conflict with their spouse during inpatient stroke rehabilitation, as reported by hospital staff. In addition, one in seven couples separated within three months of the stroke (Teasell

et al., 2000). Sex of the healthy spouse does not appear to be significant in relation to these trends (Visser-Meily et al., 2005b).

Behavioural outcomes of the children of young adults one year post stroke could often be predicted by their behaviours at the start of rehabilitation process (Visser-Meily et al., 2005b). During inpatient rehabilitation, 22% of young patients appeared to experience conflict with their children (Teasell et al., 2000). The health statuses of the spouse and children were not affected by the severity of stroke (Visser-Meily et al., 2005b). However, Visser-Meily et al. (2005a) speculated that stroke severity has an impact on the amount of support a family received from the hospital rehabilitation staff. Some patients have reported that the inherent responsibilities of being a parent impedes or conflicts with their time to focus on recovering from their stroke (Martinsen et al., 2012). Longer hospitalization appeared to correlate with the amount of attention rehabilitation staff gave children of young patients, although inpatient rehabilitation staff did not pay more attention to children with adjustment problems (Visser-Meily et al., 2005a).

With severe stroke, Silverstone and Horowitz (1987) noted that families often find themselves in a position of having to provide skilled nursing care for which they are not experienced and have received no formal training. They often have no choice but to learn the tasks by trial and error. With older patients, family roles often become reversed, as other family members struggle to fill the void left by the patient post stroke (Teasell et al., 2000). In the case of young patients, this role reversal is less apparent. In contrast, old roles are sometimes reassumed, in particular when a parent must regain care for a previously independent child (Teasell et al., 2000).

Caregivers of individuals post stroke are known to suffer from higher rates of depression and deterioration in their own health (Kinsella & Duffy, 1979). Cameron et al. (2011) found that caregivers reported more emotional distress when caring for individuals who were exhibiting more depressive symptoms and cognitive impairment post stroke. The authors also found greater distress when caregivers were younger, female, in poorer physical health, reported less mastery, and experienced more lifestyle interference.

Additional stress is applied when the caregiver of a young patient is their spouse. In a series of structured interviews with young patients and their spouses, Quinn et al. (2014) observed that relationships tended to shift from ones with equal and romantic engagement to ones mimicking a parent-child relationship. Some caregivers reported feeling the need to be stronger and more protective of their spouse, but felt as though this new relationship was not a marital relationship. In another study, Lawrence and Kinn (2013) interviewed family members of young patients following a stroke. Common themes identified were uncertainty regarding the future, worry for recurrent stroke, and frustration with the lower functional ability of the patient and the impact it had on the family. In the case of younger patient where the primary caregiver is the spouse, there are often the added responsibilities of caring for children (Visser-Meily et al., 2005b).

***Conclusions Regarding Family Stress for Younger Patients Post Stroke***

***Younger patients tend to achieve higher levels of functional recovery and independence post stroke than older patients, which commonly puts less stress on caregivers and close relations.***

***Younger patients tend to experience different social and adjustment issues post stroke compared to older stroke patients.***

***Caregivers reported more emotional distress when caring for patients exhibiting more depressive symptoms and greater cognitive impairment post stroke.***

***Improved recovery of young patients post stroke tends to put less stress on caregivers. However, caregiver struggles are often associated with changes in relationships and difficulty adjusting.***

## 21.7 Institutionalization

For patients with significant disabilities and insufficient social supports following stroke, institutionalization becomes an important consideration. Teasell et al. (2000) reported institutionalization following formal rehabilitation occurred in approximately 5% of patients under the age of 50. Placement of an individual into a chronic care facility most often occurs when severe stroke is matched with lack of a supportive caregiver (Teasell et al., 2000). When a caregiver is present, institutionalization tends to occur in cases of deterioration in the caregiver's health or an inability to cope with the continuous stress caused by increased care requirements (Boxall & McKercher, 1990; Churchill, 1993; Colerick & George, 1986; Horowitz, 1985). Fortunately, institutionalization is infrequent in young stroke patients. Young patients with severe stroke often have longer hospitalizations than older cohorts (Black-Schaffer & Winston, 2004). This finding has been attributed to older patients with severe stroke being recognized as having lower odds of functional recovery, and so they are more promptly discharged to nursing homes or institutionalized care. A longer hospital stay for younger patients may result in greater rehabilitation gains and a greater likelihood of returning home. Moreover, nursing homes are often reluctant to accept younger adults (Black-Schaffer & Winston, 2004).

Overall, a minimal number of young patients are institutionalized post stroke. Teasell et al. (2000) found that young patients were institutionalized due to a combination of severe, disabling stroke and an unwilling, unable, or absent caregiver. Younger patients also tended to be institutionalized at a lower rate over time than older patients. In a study by Schnitzler et al. (2014), the rate of institutionalization was lowest in patients aged 18 to 59 years and increased with age (18-59 years: 2.0%; 60-74 years: 3.7%; 75-84 years: 10.8%; ≥85 years: 27.3%). The authors also found that young patients who were institutionalized post stroke had significantly poorer functional outcomes according to the Modified Rankin Scale (mRS) compared to those who were discharged home. Good functional outcomes (mRS=0-1) were only observed in 10% of institutionalized young patients compared to 61.3% of young patients living at home. Poor functional outcomes (mRS=4-5) were observed in 43.5% of institutionalized young patients compared to 6.0% of young patients living at home. Similar results were observed in other studies investigating institutionalization of young patients post stroke (Adunsky et al., 1992; Falconer et al., 1994; Lindberg et al., 1992). However, the institutionalization of young patients remains an understudied area, and so further research is required to elucidate the associated factors.

***Conclusions Regarding Institutionalization of Younger Patients Post Stroke***

***Institutionalization is required infrequently in young patients post stroke as a result of better prognosis and greater availability of caregivers.***

***Functional improvement was found to be more significant when young patients were discharged home post stroke than when they were institutionalized.***

***Institutionalization is required infrequently in young patients post stroke, and is generally associated with severe stroke and limited social support.***

## 21.8 Return to Work

Vocational issues are a facet of rehabilitation unique to the young stroke population. Patients younger than 55 years of age are the most likely to return to work (Howard et al., 1985). Elderly patients rarely have a vocational engagement prior to stroke, and so occupational retraining is uncommon. However, younger patients view vocational issues as a primary concern for stroke rehabilitation (Teasell et al., 2000). For more information, see Chapter 19: Community Reintegration.

According to Monga (1997), "*The rehabilitation community has devoted only limited effort to the task of defining what is meant by the phrase return to work, to develop measures of vocational function, to applying these measures to patient populations, and to tracking return to work as a measure of rehabilitation outcome. In the published studies, the investigators do not all mean the same thing by 'work'; for example, some include homemaking and study but others only competitive employment, and some restrict it to former employment but others do not specify it at all. The age ranges of groups studied differ widely, with some studies including persons 65 years old and older and others considering only patients younger than 30 or 45 years of age"*.

There is also variability in the reported rates of return to work following stroke. Some studies show that few young patients are able to return to previous or any full-time employment one year post stroke, even if physical deficits are minimal (Glozier et al., 2008). Limitations including headache, fatigue, anxiety, irritation, and memory problems have accounted for reasons that individuals have not resumed a regular work schedule (Malm et al., 1998). Other research has found a relatively high rate (75%) of return to work for young individuals within one year post stroke, most within two to three months (Hackett et al., 2012). Some studies have shown that individuals tend to not return to their previous employment after stroke (Brooks et al., 1987; Coughlan & Humphrey, 1982; Howard et al., 1985; Isaacs et al., 1976).

Several factors have been identified as significant predictors of post-stroke return to work such as age, sex, functional status, psychiatric illness, and education level (Bergmann et al., 1991; Glozier et al., 2008; Howard et al., 1985; Peters et al., 2013). Howard et al. (1985) reported that age, race, occupation, disability, and lesion location were significant factors influencing return to work potential. They also found that individuals in managerial positions were most likely to return to work. Similarly, Saeki et al. (1993; 2010) reported that individuals were more likely to return to work post stroke if they had no apraxia, limited residual muscle weakness, and 'white collar' occupations. Maaijwee et al. (2014), however, found stroke severity and onset to be the only factors significantly associated with return to work. The authors also failed to find an association between skill level measured by education and employment post stroke.

Adaptations made during return to work include a reduction in the number and/or complexity of tasks performed and changes to the work schedule (Black-Schaffer & Osberg, 1990; Hackett et al., 2012). Black-Schaffer and Lemieux (1994) found that patients who returned to work post-stroke resumed secretarial/clerical positions or professional/technical positions. They attributed the higher success rate for 'white collar' positions to better pay, education, and work conditions, as well as less physically demanding tasks. same authors also noted that these jobs were more 'attractive', that workers had greater work autonomy, and that fellow coworkers were more likely to accommodate the individual's acquired disability at work (Black-Schaffer & Lemieux, 1994). Among patients with left-side hemiplegia, Weisbroth et al. (1971) found that those with better ambulation, upper extremity use, and abstract reasoning were more likely to return to work. Patients with right-side hemiplegia with milder communication and cognitive deficits also had better vocational outcomes (Weisbroth et al., 1971). A

distinct negative correlation between aphasia and return to work has been demonstrated in other research (Black-Schaffer & Osberg, 1990).

Cognitive deficits after stroke are recognized as an important factor in determining return to work. Unfortunately, many of these cognitive deficits are subtle or not readily apparent on general examination (Black-Schaffer & Lemieux, 1994). In such cases, neuropsychological testing may be required in order to accurately delineate the extent of cognitive problems and determine how they might impact the patient's eventual return to work (Lindberg et al., 1992; Ljunggren et al., 1985). Kauranen et al. (2013) found that the inability to return to work at six months post stroke was significantly correlated with cognitive deficits in psychomotor speed, executive function, and episodic memory both at the initial assessment and follow-up. Compared to young patients without a cognitive deficit, those with a deficit had twice the odds of being unable to return to work (Kauranen et al., 2013). The authors also noted a high level of functional recovery in the studied population, and so the low rate of return to work (41%) was mainly attributed to severe cognitive impairments. Cognitive impairments including memory deficits, anosognosia, aphasia, indifference, and emotional lability have all been shown to reduce the likelihood of returning to work post-stroke (Graham et al., 2011).

Glozier et al. (2008) found that 53% of young patients returned to full-time employment after their first stroke. The inability to return to work frequently leads to emotional and financial hardships for individuals and their families (Churchill, 1993). To address this issue, The Stroke Association & Different Strokes published a set of recommendations, Getting Back to Work after Stroke (Barker, 2006).

**Table 21.8.1 Summary of *Getting Back to Work after Stroke*** (Barker, 2006)

| **Prospective Goals** |
|---|
| • Full implementation of the proposals in the National Service Framework for long-term conditions for local rehabilitation services and specialist vocational rehabilitation services.<br>• More early supported discharge services in hospitals to help support stroke survivors in getting back home and into the community.<br>• More take-up by Primary Care Trusts and local authorities of the support services offered by voluntary organizations.<br>• Access to a comprehensive rehabilitation service that is staffed by a multidisciplinary team including physiotherapists, occupational therapists, speech and language therapists, and psychologists. |
| **Recommendations** |
| • Health and social care professionals have more education on the impact of stroke on people of working age and the subsequent needs of this group.<br>• Greater coordination and integration between health and social services and other agencies in the planning and delivery of services.<br>• Personalized care plans that aim to get the stroke survivor fit for work should be in place before the stroke survivor leaves the hospital.<br>• Rehabilitation should go further than a minimal functional level and continue as long as it is benefiting the stroke survivor.<br>• Rehabilitation should provide more emotional and psychological support.<br>• Stroke survivors and their families are to be informed of all the support that is available to them, both statutory and voluntary.<br>• Rehabilitation staff should be designated to deal with vocational/work related issues.<br>• There should be greater liaison between health/social care professionals and employers.<br>• There should be more vocational rehabilitation services specifically designed to meet the needs of people with long-term neurological conditions. |

***Conclusions Regarding Return to Work for Younger Patients Post Stroke***

***Vocational issues are important for young patients post stroke.***

***Inability to return to full employment is associated with more severe stroke, cognitive impairment, poor functional recovery, and working class position.***

***Reported rates of return to work one year post stroke range from 7% to 75%.***

***Vocational issues are often neglected in stroke rehabilitation of young patients. These issues are influenced by job type, cognitive ability, functional recovery, and stroke severity.***

## 21.9 Ongoing Care

The unique needs of young individuals post stroke are understudied (Dixon et al., 2007). Differences in a young individual's life situation compared to their older counterparts would assume greater focus should be given to psychosocial issues (Teasell et al., 2000). The impact that the stroke has had on a young individual can lead to both subtle and major social issues, including patients doubting the validity of their own disability (Stone, 2005). Employers and professionals within the community should try to focus on meeting the needs of patients and their families in order to facilitate participation and independence post stroke (Kersten et al., 2002).

The improved outcomes seen by young people post-stroke often reflect less of a need for continuous primary care. However, prevention of a second stroke is necessary and treatment is similar to that of older cohorts (Hindfelt & Nilsson, 1977). Studies investigating the incidence of recurrent stroke in young patients have found recurrent stroke to occur in 0.7% to 19.2% of patients (Bogousslavsky & Regli, 1987; Eun et al., 2013). In a long-term follow-up study, Hindfelt and Nilsson (1992) followed 74 young adults for 13-26 years after ischemic stroke. Common health concerns included post-apoplectic epilepsy (12.9%), depression (11.3%), muscular pain (9.6%), back pain (8.1%), and hypertension (8.1%). Further, a long-term follow up study by Naess et al. (2004) found young patients had a high number of modifiable risk factors for stroke and highlighted the need for increased efforts towards secondary stroke prevention.

Post-stroke fatigue (PSF) is known to be related with higher mortality rates, lower functional outcomes, and depression in older patients (Naess et al., 2005a), but is relatively unstudied in younger patients. Naess et al. (2005a) suggested that PSF in young adults can negatively affect scholastic, vocational, and social pursuits. The authors observed that patients with PSF were independently associated with unfavourable functional outcomes and unemployment at a mean of six years post-stroke. Maaijwee et al. (2015) also found PSF to be significantly associated with a poor functional outcome, depressive symptoms, and deficits in executive function. As well, Sobreiro et al. (2014) found significant associations between PSF and poor performance on a test of executive function. It has been demonstrated that the prevalence of PSF does not differ between different lesion locations, which the authors attributed to the initial characteristics of stroke not being a long-term determinant of fatigue (Maaijwee et al., 2015). For more information, see Chapter 17: Medical Complications Post Stroke.

In addition to PSF, young patients can experience anxiety and depressive symptoms post stroke (Chen et al., 2014). The incidence of anxious or depressive symptoms was found to be significantly greater post stroke in young patients compared to healthy controls (53% vs. 36%) (Palmcrantz et al., 2014). One study found that post-stroke depression (PSD) was present in 26.9% of patients aged 15-44 (Naess et al.,

2005a). In addition, compared to older cohorts, differences in severity but not incidence of depression were found (Naess et al., 2005b). The authors also found alcoholism, pre-stroke depressive symptoms, and severe neurological deficits upon admission to be associated with a higher risk of PSD (Naess et al., 2005b). In contrast, Tanislav et al. (2015) found clinically relevant depressive symptoms in young adults following stroke to be significantly more prevalent in older patients (18-24 years: 3.5%; 25-34 years: 7.4%; 35-44 years: 9.4%; 45-55 years: 11.1%). For more information, Chapter 18: Post-Stroke Depression.

The stroke event and the rehabilitation process are consistently acknowledged as traumatic events (Dixon et al., 2007; Röding et al., 2003; Stone, 2005). Following stroke rehabilitation, young patients are interested in connecting with others who share similar experiences (Stone, 2007). In a series of qualitative studies, it was reported that young patients required time to come to terms with having a stroke. They also required time to cope with changes in physical abilities, work, family, and social life (Stone, 2005, 2007). Another issue associated with young stroke is sexual impairment. In a study by Bugnicourt et al. (2014), the authors found that 29% of young patients to reported sexual impairment post stroke. The authors also found that sexually impaired patients to exhibit significantly more anxious and depressive symptoms when compared to non-sexually impaired patients. However, sexual impairment in young patients post stroke is a relatively unstudied area, and so further research is required to define this association.

***Conclusions Regarding Ongoing Care of Younger Patients Post Stroke***

***Young patients need to be aware of possible long-term health consequences post stroke, including recurrent stroke and sexual impairment.***
***Depression, anxiety, and fatigue can occur in young patients post stroke.***

***Young patients need to be connected with support organizations and individuals with similar experiences.***

***Young patients tend to have unique psychosocial and supportive needs post stroke rather than specific health concerns.***

## Summary

1. ***The incidence of stroke in young patients varies considerably across reports, ranging from 3 to 44 out of 100,000.***
2. ***The incidence of stroke in young patients is notably lower than in older patients.***
3. ***The incidence of stroke in young patients has increased over time.***
4. ***Up to one third of strokes in young people are of unknown etiology. However, this proportion is decreasing as diagnostic methods improve.***
5. ***The most common causes for hemorrhagic stroke in young patients include hypertension, arteriovenous malformation, ruptured aneurysm, or a combination of these factors.***
6. ***The majority of strokes in young patients are ischemic. Cardiac embolism is a common cause for patients younger than 40, while atherosclerosis is a common cause for patients aged 40-49.***
7. ***Uncommon etiologies are likely in stroke patients under the age of 30.***
8. ***There are many uncommon etiologies that have been recognized as risk factors for stroke in young patients, including but not limited to migraines, non-atheroclerotic vasculopathy, mitral valve prolapse, multifocal intracranial stenosis, extracranial dissection, and cardioembolism.***
9. ***Smoking and hypertension are the most considerable risk factors for stroke in the young population.***
10. ***Hyperlipidemia, diabetes mellitus, and elevated plasma homocysteine level are risk factors for stroke in the young population, particularly for those older than 35.***
11. ***Drug use is an uncommon risk factor for stroke in general but is more common in the younger population.***
12. ***Alcohol-related stroke events in the young population are relative to the amount consumed: one to two alcoholic beverages daily may reduce the risk of stroke, while excessive alcohol consumption can be a significant risk factor for stroke.***
13. ***Migraine with aura is a risk factor for stroke in the young population, with young women at an elevated risk.***
14. ***Oral contraceptives play minor role in risk of stroke in the young population when paired with other factors.***
15. ***Further research is required to determine whether chlamydia pneumoniae is a risk factor for stroke in the young population.***
16. ***Previous stroke in young patients is less common than in older patients.***
17. ***Sex appears to be related to age at stroke onset, with young patients under the age of 35 more likely to be female and above the age of 35 more likely to be male.***
18. ***Race appears to be an important risk factor for stroke in young populations, with elevated risk for young Black patients.***
19. ***Atrial fibrillation appears to be an uncommon and understudied risk factor for stroke in young patients.***
20. ***Mitral valve prolapse appears to be a minimal risk factor and infrequent sole etiology for stroke in young patients.***

21. ***The significance of family history of stroke and patent foramen ovale as risk factors for stroke in young patients is unclear.***
22. ***Pregnancy and postpartum state are unique periods of elevated stroke risk in young female patients.***
23. ***Young patients have better neurological recovery, less functional disability, and greater long-term survival post stroke than older patients.***
24. ***Impaired cognitive performance and recurrent stroke may be associated with post-stroke recovery in young patients.***
25. ***Rehabilitation of young patients post stroke is similar to that of older patients, with the main differences being the nature of neurological recovery and associated social issues.***
26. ***Stroke rehabilitation programs with an emphasis on socialization and community integration could be effective for young patients.***
27. ***Younger patients tend to achieve higher levels of functional recovery and independence post stroke than older patients, which commonly puts less stress on caregivers and close relations.***
28. ***Younger patients tend to experience different social and adjustment issues post stroke compared to older stroke patients.***
29. ***Caregivers reported more emotional distress when caring for patients exhibiting more depressive symptoms and greater cognitive impairment post stroke.***
30. ***Institutionalization is required infrequently in young patients post stroke as a result of better prognosis and greater availability of caregivers.***
31. ***Functional improvement was found to be more significant when young patients were discharged home post stroke than when they were institutionalized.***
32. ***Vocational issues are important for young patients post stroke.***
33. ***Inability to return to full employment is associated with more severe stroke, cognitive impairment, poor functional recovery, and working class position.***
34. ***Reported rates of return to work one year post stroke range from 7% to 75%.***
35. ***Young patients need to be aware of possible long-term health consequences post stroke, including recurrent stroke and sexual impairment.***
36. ***Depression, anxiety, and fatigue can occur in young patients post stroke.***
37. ***Young patients need to be connected with support organizations and individuals with similar experiences.***

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