Original Article

Quality Indicators of Intravenous Thrombolysis from North India

Akanksha Grace William, Aman Pannu, Mahesh Pundlik Kate, Vineeth Jaison, Leenu Gupta, Smrithi Bose, Rajeshwar Sahonta, Ivy Sebastian, Jeyaraj Durai Pandian

Department of Neurology, Christian Medical College, Ludhiana, Punjab, India

Abstract

Background: Data on intravenous (IV) thrombolysis using tissue plasminogen activator (tPA) are limited from low- and middle-income countries. We aimed to assess the quality indicators of IV thrombolysis in our stroke unit. **Methods** All stroke patients admitted in our hospital from October 2008 to April 2017 were included in this study. Data were collected prospectively by trained research staff in a detailed case record form. Outcome was assessed using modified Rankin Scale (mRS, 0–1 good outcome). **Results:** Of the total 4720 stroke patients seen, 944 (20%) came within window period (<4.5 h). Of these, 214 (4.5%) were eligible for thrombolysis and 170 (3.6%) were thrombolysed, relatives of 23 (23/214, 10.7%) patients denied consent, and 21 (9.8%) patients could not afford tPA. The mean age of thrombolysed patients was 58.4 (range 19–95) years. Median NIHSS at admission was 12 (interquartile range 2–24). Average onset-to-door (O-D) time was 76.8 (5–219) min, door-to-examination (D-E) time was 17.8 (5–105) min, door-to-CT (D-CT) time was 48 (1–205) min, and door-to-needle (D-N) time was 90 (20–285) min. At 6 months, 110 (64.7%) patients were contactable and 82 (74.5%) patients had good outcome (mRS 0–1). **Conclusion:** Thrombolysis rate has steadily increased at the center without undue adverse effects even in the elderly. D-E and D-CT times have reduced, but O-D and D-N times need further improvement. More patients could be thrombolysed if the cost of tPA is reduced and the consent process is waived.

Keywords: Door-to-CT time, door-to-examination time, door-to-needle time, low- and middle-income countries, onset-to-door time, tissue plasminogen activator

Introduction

Intravenous (IV) tissue plasminogen activator (tPA) is the only approved medical treatment for acute ischemic stroke within 0–4.5 h.[1] Data on tPA including that of treatment offered, reasons for not administration, and outcome are elucidated from developed countries[2] while limited data are available from low- and middle-income countries (LMICs). In 2011, American Heart Association/American Stroke Association formed Stroke Performance Oversight Committee to develop stroke treatment performance and quality measures.[3] This enabled health-care professionals to uphold the standard of care and continually improve stroke care facilities. The quality of stroke care is now measured and is increasingly reported from the developed world.[4,5]

In India, there are between 35 and 50 stroke units (SUs) and nearly 2000 patients are thrombolysed every year.[6,7] Data on hyperacute stroke care, time taken for imaging, and treatment are limited from Indian subcontinent.[8,9] Thus, this study was designed to assess the quality of hyperacute stroke care using thrombolysis rate, onset-to-door (O-D), door-to-examination (D-E), door-to-imaging (D-CT), and door-to-needle (D-N) time in our SU.

Access this article online

Quick Response Code:

Website: www.annalsofian.org

DOI: 10.4103/aian.AIAN_277_17

Methods

This prospective study was carried out in the SU of tertiary care center in North India, from October 2008 to April 2017. The center is an academic teaching hospital with a well-established SU, stroke treatment protocol, 24 h on-call neurologist, imaging (computed tomography [CT] and magnetic resonance imaging), and thrombolysis facility. Hospital electronic database captures patient arrival time and

Address for correspondence: Dr. Jeyaraj Durai Pandian, Professor and Head, Department of Neurology Christian Medical College, Ludhiana -141 008, Punjab, India.
E mail: jeyarajpandian@hotmail.com; jeyarajpandian@yahoo.co.in

How to cite this article: William AG, Pannu A, Kate MP, Jaison V, Gupta L, Bose S, *et al*. Quality indicators of intravenous thrombolysis from North India. Ann Indian Acad Neurol 2017;20:393-8.

imaging time. tPA bolus and infusion time were noted from nurses chart. Onset time was noted as the time when the patient was last seen normal. O-D time was the time taken to arrive in the emergency department (ED), D-CT was the time taken to initiate CT scan, and D-N was the time taken to initiate tPA bolus dose. Intracranial hemorrhage (ICH) was defined as CT documented hemorrhage with deterioration in NIHSS of ≥4 within 36 h of thrombolysis. The dose was 0.9 mg/kg for the study period (except for 2013–2016 where it was 0.6 mg/kg).

Stroke pathway

For any patient suspected to have stroke, the on-call neurologist is alerted by the emergency medical officer. The neurologist examines the patient in ED, and after a quick assessment, the patient is transferred to imaging facility. If thrombolysis can be offered, consent is taken and patient is shifted to SU where he/she is thrombolysed by nurses trained in stroke care.

All stroke patients who were given tPA during the study period were included in the study. The study period was divided into two halves with the first half between October 2008 and December 2012 and the second half from January 2013-April 2017. After discharge, follow-up was done face-to-face interview and/or telephonically at 6 months. Modified Rankin Scale (mRS) was used; (0-1) was considered good outcome.

Statistical analysis

Data are presented as mean ± standard deviation or median (interquartile range, [IQR]). The primary outcome measure was the 6-month mRS, dichotomized as good (mRS 0–1) or poor (mRS 2–6). IBM SPSS, version 21.0 Armonk, NY: IBM corp., was used for analyses.

Results

Demography

In the study period, 4720 stroke patients were admitted in SU. Of these, 944 (20%) came within window period (0–4.5 h of onset); among them, 750 (15.8%) had ischemic stroke and 214 (4.5%) were eligible for tPA. Thrombolysis rate was 170/4720 (3.6%) [Figure 1]. The most common reason for not receiving tPA was delay or denial of consent by relatives (23; 23/214, 10%) followed by unaffordability (21; 21/214, 9.8%). The mean age of thrombolysed patients was 58.4 (range 19–90) years, of whom 112 (65.9%) were men and 14 patients were ≥80 years. The median NIHSS at admission was 12 (IQR 7–17).

Risk factors

In decreasing order of frequency, the risk factors were hypertension (n = 75, 44.1%), diabetes mellitus (n = 39, 22.9%), valvular heart disease (n = 13, 7.6%), coronary artery disease (n = 12, 7%), atrial fibrillation (n = 9, 5.2%), prior transient ischemic attack (n = 6, 3.5%), dyslipidemia and myocardial infarction (n = 5, 2.9%) each, smoking (n = 4, 2.3%), and alcohol (n = 3, 1.7%).

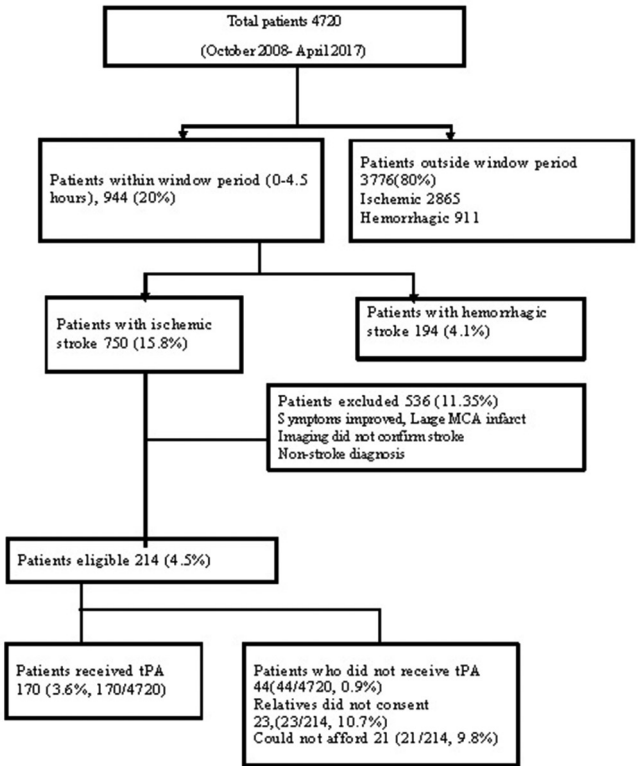

Figure 1: Patient distribution

Quality measures

The overall average O-D time was 76.8 (5–219) min, D-E time was 17.8 (5–105) min, D-CT time was 48 (1–205) min, and D-N time was 90 (20–285) min. The mean O-D time between the two periods was 63 (31–90) and 70-(43.5–121) min (P = 0.06); D-E time was 14 (6–25) and 5 (3–11.2) min (0.01); D-CT time was 60 (31.5–75) and 30 (20–60.5) min (0.01); and D-N time was 84.5 (68.2–101.5) and 85 (64.5–118) min (P = 0.98), respectively. Recommended D-E time (≤15 min) was achieved in 37 (62.7%) and 53 (47.7%, P = 0.06) patients, D-CT time (≤25 min) was achieved in 10 (16.9%) and 38 (34.2%, P = 0.01) patients, and D-N time (≤60 min) was achieved in 6 (10.2%) and 24 (21.6%, P = 0.06) patients, respectively [Table 1]. Figures 2a and 2b show number and percentage of patients thrombolysed annually and in the respective periods.

Complications

During the study period, 4 (2.3%) patients had symptomatic ICH and 2 patients in each period. Asymptomatic ICH was seen in 10 (5.8%) patients, 4 in the first half and 6 in the later half period. One patient had gastrointestinal hemorrhage and 1 patient had ecchymosis and gum bleed in the second period.

Outcome

Of the 110 (64.7%) patients who could be contacted at 6 months, good outcome (0–1) was seen in 82 (74.5%), poor outcome (2–5) was seen in 28 (25.5%), and 35 (20.6%) died.

Table 1: Quality indicators for the current study

Quality indicator	October 2008 – December 2012 (n=1780) (10)	January 2013 – April 2017 (n=2940)	*P*
Number of patients thrombolysed	59	111	0.38
Thrombolysis rate	3.3% (5/489)	3.7%	0.38
O-D (minutes)	63 (31-90)	70 (43.5-121)	0.06
D-E (minutes)	14 (6-25)	5 (3-11.25)	0.01
D-CT (minutes)	60 (31.5-75)	30 (20-60.5)	0.01
D-N (minutes)	84.5 (68.25-101.5)	85 (64.5-118)	0.98
aICH	4 (6.7)	6 (5.4)	0.74
sICH	2 (3.3)	2 (1.8)	0.60

O-D = Onset to Door, D-E = Door to Examination, D-CT = Door to Imaging Initiation, D-N Door to Needle, aICH = Asymptomatic Intracranial Hemorrhage, sICH = Symptomatic Intracranial Hemorrhage

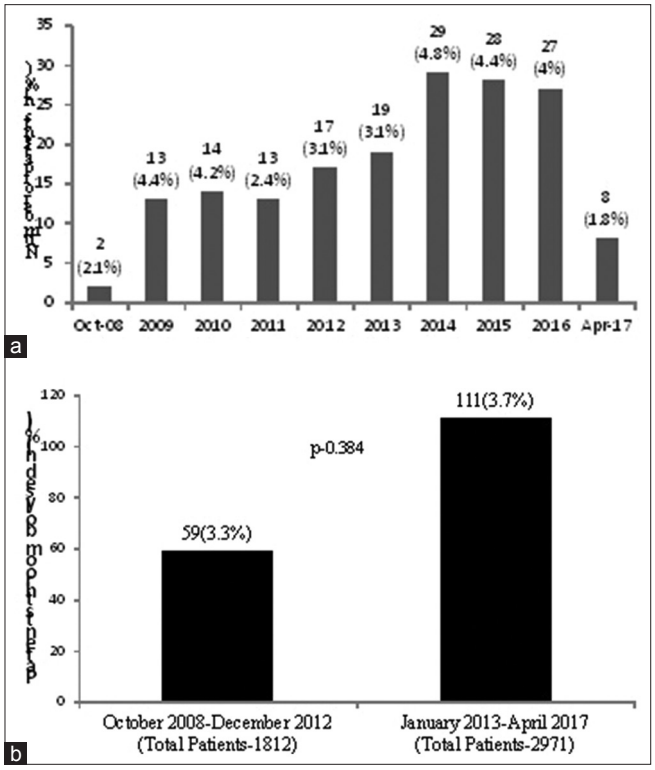

Figure 2: (a) Number of annual thrombolysed patients. (b) Comparison of thrombolysis rate between October 2008–December 2012 and January 2013–April 2017

Discussion

In this study, the overall thrombolysis rate was 3.6%, as compared to our earlier reports of 1% and 4.5%.[10,11] When the study period was dichotomized (October 2008–December 2012 and January 2013–April 2017), thrombolysis rate between the two study periods was nearly the same despite doubling in the absolute number of thrombolysed patients. This is due to a proportionate increase in the total number of stroke patients who came within the window period. This can be partly explained by the establishment of "Ludhiana population-based stroke registry,"[12] which was an epidemiologic project carried out from 2010 till 2013 by the department of neurology. As part of the registry several public awareness, campaigns and educational sessions for general practitioners and physicians were held in the city. Consequently, the number of stroke patients seen in the current study had increased six times since the last report (January 2008–November 2010, n = 715). This emphasizes that public awareness campaigns are effective in reducing the time taken for patients to arrive.

Similar thrombolysis rate has been reported from a center in Hyderabad, India (89/2593, 3.4%).[13] From another center in Northwest India, the thrombolysis rate was 31.87% (189/593). However, the authors had calculated the percentage using eligible patients instead of all stroke patients. Our center has seen a steady increase in thrombolysis rate parallel to that of some developed countries.[14,15]

Even though the number of thrombolysed patients has increased over the years, still 44 (44/214, 20.5%) eligible patients were not thrombolysed. The main reasons were delay in arrival, high cost of tPA, and denial of consent by the relatives. To decrease O-D time, the hospital organized public awareness campaigns and put up posters outside public places, for example, temples and gurudwaras. This strategy had minimal impact. Throughout the study period, only one patient utilized ambulance service to come to the hospital.

Unlike developed countries where thrombolysis is a part of standard medical treatment and the cost is covered by medical insurance, in LMICs like India, patients have to bear their own cost of treatment. Also, in India it is necessary to obtain a separate consent for thrombolysis. These two are important hurdles faced in ED for a considerable number of patients who arrived within window period in our center. Relatives of these patients often telephonically consult their primary physicians/family doctors about thrombolysis. The attending relative also consults other relatives about the cost of treatment before consenting. This delays that the decision-making excludes eligible patients from the window period.

An additional reason for delay in arrival is the time lost in consulting family/local doctor before arriving at our center.[16,17] Raising public awareness will play a major role in reducing this crucial time lost. This requires a drastic cultural change in the understanding of the community, which can be difficult to bring about even in developed countries.[18] Even though different states have ambulance services, the paramedics are not trained in identifying stroke. Their training can help in reducing this time lost. This policy can be implemented and enforced with government and private partnership. However, traffic still remains a major problem within cities of India. Patients who stay within 10 km from SU should use private vehicles to save time.[16] This pattern of using private vehicles is also seen in another study from the North India where 201 patients used ambulance services but 578 used private or public vehicles.[9] Mean O-D time in the current study was

Table 2: Compares the current study with other studies from India and Asia

Parameter	Current study	Malabar[31]	Malabar[32]	Delhi[19]	Hyderabad[13]	Chandigarh[9]	Taiwan[28]	China[29]	Thailand[22]	Vietnam[30]	Thailand[27]	Thailand[24]
Study duration	October 2008 - April 2017	May 2003 - May 2008	July 2009 - October 2012		Jan 2010 - Jan 2015	Jan 2011 - Dec 2015		Sept 2007 - Aug 2008	2001-2004	May 2006 - May 2009	Oct 2007 - Jan 2009	Jan 2010 - Dec 2012
Age (range) years	58.43±14	(35-78)	65 (44-85)	66 (32-82)	55±15.2	60 (49-72)	67.6±12.7	65±12.6	65.5±12	57 (18-78)		64.1 (13.1)
Number of patients thrombolysed	170 (170/4720,3.6%)	57 (57/2308, 2.5%)	31	54	89 (89/2593, 3.4%).)	189	307 (91 pre stroke code; 216 post stroke code)	284/81	34	121 (2%, 121/6171)	100	914
NIHSS median (range)	12 (2-24)		10 (5-22)	15.5±2.7(11-22)	11.8±5.7	11 (6-18)	12 (7-17)		20 (9-32)	12 (5-23)	15 (3-34)	12 (8-16)
Onset to door (minutes)	76.88 (5-219)			144 (69-204)	152.7±76.6	91 (55-143.5)	58 (32-94.5)		65.2 (0-158)			
Door to examination (minutes)	17.88 (5-105)											
Door to imaging (minutes)	48.04 (1-205)			24 (10-47)	31.1±25.6	17 (10-30)	11 (9-13)					
Door to needle (minutes)	90.03 (20-285)	50 (15-120)	65 (15-150)	26.8 (25-67)		63 (48.5-85)	51 (43-64)	116 (70-150)	72.6 (20-150)	75 (43-107)	54 (15-125)	60 (47-78)
Symptomatic intracranial hemorrhage	4	1 (1.7%)	0			5	10 (4.6%)					
mRS			mRS ≤2=240; mRS >2=218			75/189 (0-1)	(0-2 in 49.5%)					
Onset to treatment (minutes)						165 (127.5-225)	125 (90.3-157)	180 (150-228)				

NIHSS = National institute of health stroke scale

longer than the previous report from our center[11] but less than that of other reports from India.[13,19]

Among 44 (20.5%) patients who were not thrombolysed, 21 (9.8%) patients could not afford tPA. The government can subsidize its cost in private hospitals and offer it free of cost in government hospitals. This is already being done by the states of Punjab and Himachal Pradesh, India, where the government is offering tPA free of charge in local government hospitals.[20,21] This subsidy can perhaps even be included it in the national insurance scheme similar to that of Thailand where treatment of all patients is covered by the government.[22] It is also important to bear in mind that offering tPA free of charge should be accompanied by parallel establishment of SUs and training of stroke-care staff.[23] Similar reasons for not thrombolysing eligible patients were observed in other studies from India.[9,11,13]

D-CT time in the current study was longer than three studies reported from India.[9,13,19] These were 17 (10–30) min, 31 ± 25.6 min, and 24 (10–47) min, respectively. The delay most commonly occurs when relatives are reluctant to make a decision about admitting and imaging the patient. In our center, stroke patients are given priority for imaging, minimizing this delay.

D-N time in the current study was longer as compared to the studies from Delhi (26.8, 25–67 min), Chandigarh 63 (48.5–85 min), and Thailand 60 (47–78 min).[9,19,24] However, when compared to earlier report from our center, this time has shortened. Further shortening can be brought about by initiating tPA in CT scan room as done in Melbourne and Finland.[25,26] In another study from Thailand, 100 patients were thrombolysed within 54 min of arrival.[27] This was achieved by establishing an "acute stroke referral system". In this system, hospitals within 80 km of Thammasat Hospital referred their suspected stroke patients to Thammasat Hospital timely. Upon arrival, they were screened and stroke fast track was activated for patients within window period. This hospital is situated in suburban Bangkok. Perhaps, establishing similar referral systems in crowded Indian (and Asian) cities can make thrombolysis possible for these patients. A similar "stroke code" was established in Taiwan in 2010.[28] Comparison of quality indicators between prestroke era (January 2006-July 2010) and stroke code era (August 2010-July 2013) revealed improvement in O-D time, D-CT time, and D-N time after establishing a "stroke code". In comparison to this study, the current study has room for improvement by strengthening the stroke pathway and reducing D-N time.

Compared to Chinese National Stroke Registry data (September 2007–August 2008), where 284 patients were thrombolysed, D-N time of the present study was shorter (116 [70–150] min).[29] The study added that patients who had higher income (>1000 Yuan/month) were twice as likely to receive tPA. Soon after these results, tPA was covered by the national health-care insurance and thrombolysis rate is expected to increase. Perhaps, a similar anticipated increase in thrombolysis rate in India is also possible if health insurance covers tPA.

The current study is comparable to other studies from Asia, namely, Vietnam,[30] Taiwan,[28] China,[29] and Thailand[22] where very few patients come within window period. Similar lack of understanding to act quickly and poor ambulance services in India is faced by these countries as well. This reinforces the urgent need for public awareness and establishing well-equipped ambulance systems in Asia Table 2.

Strengths and limitations

The center has been able to do regular reviews over a long period of time. The infrastructure for endovascular tPA will be soon available for patients in the current program. This is a single-centered study, but it has major findings which are applicable to many countries in Asia and LMICs.

Conclusion

Thrombolysis rate has increased without undue adverse effects even in the elderly. D-E and D-CT times have reduced, but O-D and D-N times need further improvement. More patients could be thrombolysed if the cost of tPA is reduced and consent process is waived.

Acknowledgment

We would like to thank Ms. Deepika Sharma, Dr. Deepti Arora, and Ms. Shalini Jamual, for data entry.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Hacke W, Kaste M, Bluhmki E, Brozman M, Dávalos A, Guidetti D, *et al.* Thrombolysis with alteplase 3 to 4.5 hours after acute ischemic stroke. N Engl J Med 2008;359:1317-29.
2. Millán M, Dorado L, Dávalos A. Fibrinolytic therapy in acute stroke. Curr Cardiol Rev 2010;6:218-26.
3. Smith EE, Saver JL, Alexander DN, Furie KL, Hopkins LN, Katzan IL, *et al.* Clinical performance measures for adults hospitalized with acute ischemic stroke: Performance measures for healthcare professionals from the American heart association/American stroke association. Stroke 2014;45:3472-98.
4. Joshi P, Fink J, Barber PA, Davis A, Lanford J, Seymour A, *et al.* Stroke thrombolysis in New Zealand: Data from the first 6 months of the New Zealand Thrombolysis Register. N Z Med J 2016;129:44-9.
5. Ganesh A, Camden M, Lindsay P, Kapral MK, Coté R, Fang J, *et al.* The quality of treatment of hyperacute ischemic stroke in Canada: A retrospective chart audit. CMAJ Open 2014;2:E233-9.
6. Pandian JD, Sudhan P. Stroke epidemiology and stroke care services in India. J Stroke 2013;15:128-34.
7. Wasay M, Khatri IA, Kaul S. Stroke in South Asian countries. Nat Rev Neurol 2014;10:135-43.
8. Banerjee TK, Das SK. Fifty years of stroke researches in India. Ann Indian Acad Neurol 2016;19:1-8.
9. Khurana D, Das B, Kumar A, Kumar S A, Khandelwal N, Lal V, *et al.* Temporal trends in intravenous thrombolysis in acute ischemic stroke: Experience from a tertiary care center in India. J Stroke Cerebrovasc Dis 2017;26:1266-73.

10. Pandian JD, Sethi V, Dhillon R, Kaur R, Padala S, Chakravorty R, *et al.* Is intravenous thrombolysis feasible in a developing country? Cerebrovasc Dis 2005;20:134-6.
11. Pandian JD, Bhullar RS, Kaur P, Dhillon S, Toor G, Singh Y, *et al.* Trends in the use of intravenous recombinant tissue plasminogen activator from Northwest India. Int J Stroke 2012;7:363-4.
12. Pandian JD, Singh G, Kaur P, Bansal R, Paul BS, Singla M, *et al.* Incidence, short-term outcome, and spatial distribution of stroke patients in Ludhiana, India. Neurology 2016;86:425-33.
13. Pidaparthi L, Kotha A, Aleti VR, Kohat AK, Kandadai MR, Turaga S, *et al.* Factors influencing nonadministration of thrombolytic therapy in early arrival strokes in a university hospital in Hyderabad, India. Ann Indian Acad Neurol 2016;19:351-5.
14. Adeoye O, Hornung R, Khatri P, Kleindorfer D. Recombinant tissue-type plasminogen activator use for ischemic stroke in the United States: A doubling of treatment rates over the course of 5 years. Stroke 2011;42:1952-5.
15. Singer OC, Hamann GF, Misselwitz B, Steinmetz H, Foerch C, Arbeitsgruppe Schlaganfall Hessen. *et al.* Time trends in systemic thrombolysis in a large hospital-based stroke registry. Cerebrovasc Dis 2012;33:316-21.
16. Pandian JD, Kalra G, Jaison A, Deepak SS, Shamsher S, Padala S, *et al.* Factors delaying admission to a hospital-based stroke unit in India. J Stroke Cerebrovasc Dis 2006;15:81-7.
17. Ashraf VV, Maneesh M, Praveenkumar R, Saifudheen K, Girija AS. Factors delaying hospital arrival of patients with acute stroke. Ann Indian Acad Neurol 2015;18:162-6.
18. Gill S. Reducing door to needle time for stroke thrombolysis. BMJ Qual Improv Rep 2014;3: pii: u204771.w2199.
19. Padma MV, Singh MB, Bhatia R, Srivastava A, Tripathi M, Shukla G, *et al.* Hyperacute thrombolysis with IV rtPA of acute ischemic stroke: Efficacy and safety profile of 54 patients at a tertiary referral center in a developing country. Neurol India 2007;55:46-9.
20. Health. 5.years.pdf. Available from: http://www.pbhealth.gov.in/Health%205%20years.pdf. [Last accessed on 2017 May 31].
21. Sharma S, Padma MV, Bhardwaj A, Sharma A, Sawal N, Thakur S, *et al.* Telestroke in resource-poor developing country model. Neurol India 2016;64:934-40.
22. Suwanwela NC, Phanthumchinda K, Likitjaroen Y. Thrombolytic therapy in acute ischemic stroke in Asia: The first prospective evaluation. Clin Neurol Neurosurg 2006;108:549-52.
23. Pandian JD, Joy SA, Justin M, Premkumar AJ, John J, George AD, *et al.* Impact of stroke unit care: An Indian perspective. Int J Stroke 2011;6:372-3.
24. Kongbunkiat K, Kasemsap N, Tiamkao S, Chotmongkol V, Sawanyawisuth K, Mekawichi P, *et al*. Thrombolysis in ischaemic stroke in rural North East Thailand by neurologist and non-neurologists. Neurol Asia 2016;21:325-31.
25. Meretoja A, Weir L, Ugalde M, Yassi N, Yan B, Hand P, *et al.* Helsinki model cut stroke thrombolysis delays to 25 minutes in Melbourne in only 4 months. Neurology 2013;81:1071-6.
26. Meretoja A, Strbian D, Mustanoja S, Tatlisumak T, Lindsberg PJ, Kaste M, *et al.* Reducing in-hospital delay to 20 minutes in stroke thrombolysis. Neurology 2012;79:306-13.
27. Muengtaweepongsa S, Dharmasaroja P, Kummark U. Outcomes of intravenous thrombolytic therapy for acute ischemic stroke with an integrated acute stroke referral network: Initial experience of a community-based hospital in a developing country. J Stroke Cerebrovasc Dis 2012;21:42-6.
28. Chen CH, Tang SC, Tsai LK, Hsieh MJ, Yeh SJ, Huang KY, *et al.* Stroke code improves intravenous thrombolysis administration in acute ischemic stroke. PLoS One 2014;9:e104862.
29. Wang Y, Liao X, Zhao X, Wang DZ, Wang C, Nguyen-Huynh MN, *et al.* Using recombinant tissue plasminogen activator to treat acute ischemic stroke in China: Analysis of the results from the Chinese National Stroke Registry (CNSR). Stroke 2011;42:1658-64.
30. Nguyen TH, Truong AL, Ngo MB, Bui CT, Dinh QV, Doan TC, *et al.* Patients with thrombolysed stroke in Vietnam have an excellent outcome: Results from the Vietnam Thrombolysis Registry. Eur J Neurol 2010;17:1188-92.
31. Salam KA, Ummer K, Kumar VGP, Noone ML, Laila A, Ragini J. Intravenous thrombolysis for acute ischemic stroke: the Malabar experience 2003 to 2008. J Clin Neurosci Off J Neurosurg Soc Australas. 2009;16:1276-8.
32. Salam KA, Ummer K, Pradeep Kumar VG, Noone ML. Intravenous thrombolysis for acute ischemic stroke in the 3- to 4.5-hour window – the Malabar experience. Int J Stroke. 2014;9:426-8.