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CLINICAL & BASIC RESEARCH

Yield of Cardiac Investigations in Patients Presenting with Acute Ischaemic Stroke

A single tertiary centre experience

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abstract: ***Objectives:*** Strokes are a major cause of morbidity and mortality. This study aimed to evaluate the effectiveness of routine cardiac investigations in identifying a cardioembolic aetiology for ischaemic strokes. ***Methods:*** This retrospective study involved patients who presented with a stroke to the Sultan Qaboos University Hospital, Muscat, Oman, between January and December 2019. ***Results:*** A total of 183 patients (mean age = 66.2 ± 13.5 years), the majority of which were male (n = 109, 59.6%), were included. The common risk factors included hypertension (74.9%), diabetes (61.7%) and hyperlipidaemia (54.6%). The middle cerebral artery was the most common artery affected, in 44 patients (24.0%). On admission, 14 (7.6%) patients were in atrial fibrillation (AF), while the rest were in sinus rhythm. The 24-hour electrocardiogram (ECG) Holter monitoring revealed no abnormalities in 135 patients. AF was observed in 15 (8.1%) patients (inclusive of the 14 who had AF on resting ECG). Furthermore, 32 (17.4%) patients had evidence of non-sustained atrial arrhythmia, and nine (4.9%) had non-sustained ventricular tachycardia. Frequent supraventricular ectopics (>30/hour) was noted on 30 patients (16.3%), while five (2.7%) patients had a high ventricular ectopic burden (>10% burden). No significant abnormalities were noted in the echocardiograms of the patients; however, 10 out of 132 (7.5%) patients presented a positive bubble echo. Enlarged left atria were found in 24 (13.1%) patients. ***Conclusion:*** The overall diagnostic yield of the abnormalities from routine cardiac testing for patients with stroke appears to be low. Targeted screening of patients with cryptogenic stroke, as suggested by newer guidelines, is recommended.

Keywords: Cerebrovascular Accidents; Echocardiography; Atrial Fibrillation; Oman.

Advances in Knowledge

- *Routine cardiac testing in patients with stroke has a low yield rate in terms of identifying the cardiac source of embolism.*
- *However, these tests help identify patients at high risk for future atrial fibrillation (AF).*

Application to Patient Care

- *Although 24-hour monitoring does not help identify all patients with AF, it identifies those at risk of AF.*
- *Careful evaluation of these patients must be performed to assess suitability for anticoagulation.*

Strokes are a leading cause of morbidity and mortality worldwide with 101 million prevalent cases reported worldwide and approximately 12.2 million incident cases of stroke in 2019.[1] Strokes are the second leading cause of death and the third leading cause of death and disability combined.[1] Hence, it is associated with increased costs and loss of productivity. In the USA alone, medical costs related to stroke have been projected to increase from approximately 75 billion dollars annually in 2010 to approximately 180 billion dollars annually by 2030; indirect costs due to loss of productivity are expected to increase from around 30 billion dollars annually to approximately 55 billion dollars annually during the same time period.[2] According to the latest data published by the World Health Organization, stroke-related deaths account for 11.1% of the total deaths, with the age-adjusted death rate being 94.98 per 100,000 population in Oman. It is the third leading cause of mortality in Oman after coronary heart disease and diabetes mellitus.[3] Additionally, the prevalence of risk factors for stroke is high among the Omani population, adding to the potential economic burden of the disease.[4]

The aetiology of ischaemic strokes can be divided into the following five categories on the basis of the Trial of ORG 10172 in Acute Stroke Treatment (TOAST) criteria: large artery atherosclerosis, cardioembolism, small vessel occlusion, stroke of other determined aetiology and stroke of undetermined ('cryptogenic') aetiology.[5] Cardioembolic stroke accounts for approximately 20–25% of all ischaemic strokes and is associated with a worse prognosis regarding disability, mortality and both early- and long-term recurrences compared with other aetiologies.[6,7]

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Sources of cardioembolism are further classified into major or minor risk sources according to their thrombo-embolic potential.[8] The most common major risk source of cardioembolism is atrial fibrillation (AF).[9] Less frequently encountered major risk sources include cardiomyopathies with left ventricular (LV) dysfunction, intracardiac thrombi, cardiac tumours, prosthetic valves and endocarditis. Minor risk sources include patent foramen ovale (PFO), atrial septum aneurysm and calcification of aortic and mitral valves.[8]

The advantage of such classification of strokes using the TOAST system (or any other similar ones) is that it has major implications for preventive management.[6] Strokes have a high incidence of recurrence, with a five-year recurrence rate of approximately 30%.[10] Identifying the aetiology of the stroke is thus critical for preventing future strokes. While the large majority of large- or small-artery strokes are treated with antiplatelet agents and statin, the long-term relative risk reduction in the recurrence of stroke offered by this treatment is only approximately 20–25%.[11] In contrast, using anticoagulants for the prevention of definitively recognised cardioembolic stroke results in a long-term relative risk reduction of 60–65%.[11] Furthermore, cardioembolic strokes are associated with much higher morbidity and mortality compared with other forms of stroke due to their tendency to cause large infarcts with poor cardiovascular support for the re-establishment of cerebral circulation. Therefore, diagnosis and prevention of cardioembolic strokes (with anticoagulation) are relatively more effective (compared to non-cardioembolic strokes) as well as cost-effective in that they prevent higher morbidity and mortality.

In this context, the American Heart Association or the American Stroke Association and the European Stroke Organisation recommend routine cardiac testing, such as a minimum of 24 hours of cardiac electrocardiogram (ECG) monitoring and a transthoracic echocardiogram (TTE), for all patients who have suffered a stroke.[11,12] The diagnostic yield from these sets of investigations is variable, with many studies recommending longer durations of cardiac monitoring to improve the diagnosis and identification of AF.[9,13] Similarly, studies have also suggested the routine use of transoesophageal echo over transthoracic echo to improve the identification of cardiac abnormalities that can predispose to strokes.[14] While the older guidelines recommended cardiac investigations in all patients presenting with a stroke, newer guidelines recommend these investigations in patients with cryptogenic strokes.[15]

In the Sultan Qaboos University Hospital (SQUH), Muscat, Oman, it is standard practice to perform 24-hour ECG Holter monitoring and a TTE (with a bubble study) for all patients presenting with an ischaemic stroke. This study aimed to assess the rate of identification of abnormalities with these tests in the institution.

Methods

All patients aged ≥18 years who were admitted with a final diagnosis of stroke between January and December 2019 at the SQUH were identified. Their electronic case records were reviewed, and only those who had undergone a full cardiac evaluation were included in the final analysis. Patients with scans that revealed an intracranial bleed, those who had died before any cardiac investigations were performed and those on whom investigations were not conducted due to presumed very poor prognosis or for other clinical reasons were excluded from the study. Patients with incomplete case records were also excluded. These patients were diagnosed to have a stroke on the basis of clinical findings and from a computed tomography scan of the brain. Carotid artery imaging and magnetic resonance imaging scans of the brain were not routinely performed.

All eligible patients had undergone 24-hour Holter ECG monitoring and a standard TTE with an agitated saline contrast study. The Holter data were analysed using SEER 1000 (GE Medical Systems Technologies Ltd., Boston, Massachusetts, USA). The abnormalities were classified as in other major studies. AF was considered if the episode lasted >30 seconds. Anything less was classified as atrial tachyarrhythmia.[16,17] The frequency of premature ventricular contractions was reported as high if the burden was greater than 10% of the total QRS complexes in a 24-hour period.[18] Frequencies between 1–10% were classified as medium and anything less was considered low. The frequency of premature atrial contractions (PACs) was considered to be high if it exceeded 30 PACs/hour (720 PACs in 24 hours), medium if it was 10–30 PACs per hour (240–720 PACs per 24 hours) and low if it was fewer than 10 PACs per hour.[19]

ECGs were performed on all patients employing a GE Vivid 7 machine (GE healthcare, Chicago, Illinois, USA) as per the standard protocol.[20] The abnormalities that were examined for included valvular abnormalities such as mitral stenosis and intracardiac masses such as vegetations, tumours or thrombi and evidence of intracardiac shunts. An agitated saline study was also performed according to the standard protocol with normal respiration and post-Valsalva manoeuvre where possible.[20] The study was positive if agitated saline was noted in the left-sided cardiac chambers in less than four cardiac cycles. This was indicative of PFO in patients or other causes leading to an intracardiac shunt. The left atrium was considered to be enlarged if it measured >4 cm in men and >3.9 cm in women. Pulmonary hypertension was defined as mild if the mean pressure was calculated to be 25–35 mmHg, moderate if it ranged from 35–45 mmHg and severe if it was >45 mmHg.[16]

The Risk of Paradoxical Embolism (RoPE) score has been developed and validated as an assessment tool to determine the probability that a PFO is responsible for a cryptogenic stroke.[21] It can be utilised when assessing patients with a PFO preceding closure. A high score correlates with the increased likelihood that a PFO is responsible for the index stroke. The PFO-attributable fractions of stroke for scores of 7, 8 and 9 are 72%, 84% and 88%, respectively, and they define a subset of patients who may benefit from PFO closure. The RoPE score for the patients was calculated, as described previously.[21]

The collected data were analysed employing the statistical software, Statistical Package for Social Sciences (SPSS), Version 22 (IBM Corp., Armonk, New York, USA). A descriptive analysis of the categorised variables was presented as proportions, and continuous variables were presented as the mean and standard deviation. The Chi-squared test was utilised to check for differences among groups for categorical variables.

Ethical approval was obtained from the Medical Research Ethical Committee of the SQUH (MREC: #1365).

Results

A total of 215 patients had been admitted with a diagnosis of stroke. Of these, 32 patients did not fulfil the inclusion criteria; subsequently, 183 patients (mean age = 66.2 ± 13.5 years), of which 109 (59.6%) were

Table 1: Characteristics of the included stroke patients (N = 183)

Characteristic	**n (%)**			***P* value***
	Total	**First stroke (n = 131)**	**Recurrent stroke (n = 52)**	
Age in years ± SD	66.2 ± 13.5	65.6 ± 13.7	67.9 ± 12.8	0.2
Gender				0.7
Male	109 (59.6)	79 (60.3)	30 (57.6)	
Female	74 (40.4)	52 (39.7)	22 (42.4)	
Diabetes	113 (61.7)	82 (62.5)	31 (59.6)	0.7
Hypertension	137 (74.9)	95(72.5)	42 (80.7)	0.2
Dyslipidaemia	100 (54.6)	66 (50.3)	34 (65.3)	0.06
Previous MI	48 (26.2)	29 (22.1)	19 (36.5)	0.04
Artery involved				0.14
MCA	44 (24.0)	25 (19.1)	19 (36.5)	
PCA	13 (7.1)	10 (7.6)	3 (5.7)	
Basilolateral	5 (2.7)	5 (3.8)	0 (0.0)	
ACA	5 (2.7)	3 (2.3)	2 (3.8)	
PICA	2 (1.1)	1 (0.7)	1 (1.9)	
ICA	2 (1.1)	2 (1.4)	0 (0.0)	
No clear artery identified	112 (61.2)	85 (64.8)	27(51.9)	
Site of hemiplegia				0.59
Right	45 (24.6)	35 (26.7)	10 (19.1)	
Left	67 (36.6)	45 (34.3)	22 (42.3)	
Indeterminate†	71 (38.8)	51 (38.9)	20 (38.4)	

SD = standard deviation; MI = myocardial infarction; MCA = middle cerebral artery; PCA = posterior cerebral artery; ACA = anterior cerebral artery; PICA = posterior inferior cerebellar artery; ICA = internal carotid artery.

**Using Chi-squared test or students t-test as appropriate. †Includes patients without hemiplegia such as lacunar infarcts or posterior circulation strokes, or where patients were comatose, making it was difficult to ascertain the site of infarct, or cases where the site of hemiplegia was not documented.*

Table 2: Electrocardiogram and Holter monitoring of the included patients (N = 183)

Test	n (%)			*P* value*
	Total	First stroke (n = 131)	Recurrent stroke (n = 52)	
Rhythm on resting ECG				0.5
Normal sinus rhythm	169 (92.3)	122 (93.1)	47 (90.3)	
Atrial fibrillation	14 (7.7)	9 (6.9)	5 (9.7)	
Holter findings				0.38
Normal	135 (73.8)	98 (74.8)	37 (71.1)	
Atrial fibrillation	15 (8.2)	9 (6.8)	6 (11.5)	
Atrial tachycardia	32 (17.5)	21 (16.0)	11 (21.1)	
SVT	4 (2.2)	4 (3.1)	0 (0.0)	
VT	9 (4.9)	5 (3.8)	0 (0.0)	
Conduction abnormalities	2 (1.1)	2 (1.5)	4 (7.6)	
PVC burden				0.21
<1%	148 (80.9)	109 (83.2)	39 (75.0)	
1%–10%	30 (16.4)	20 (15.2)	10 (19.2)	
>10%	5 (2.7)	2 (1.5)	3(5.7)	
PAC burden				0.9
<10/hr	143 (78.1)	102 (77.8)	41 (78.8)	
10–30/hr	10 (5.5)	7 (5.3)	2 (3.8)	
>30/hr	30 (16.4)	21 (16.0)	9 (17.3)	

ECG = electrocardiogram; SVT = supraventricular tachycardia; VT = ventricular tachycardia; PVC = premature ventricular contraction; PAC = premature atrial contraction.
**Using Chi-squared test.*

male and 74 (40.4%) were female, were included in the final analysis. Hypertension was the most common risk factor (74.9%), followed by diabetes (61.7%) and hyperlipidaemia (54.6%). A total of 79 (43.2%) patients had three cardiovascular risk factors, and 36 (19.7%) had two risk factors. A total of 40 patients (21.9%) had one risk factor, while 28 (15.3%) did not have any cardiovascular risk factors. The data on smoking habits were incomplete. Moreover, 26.2% of the patients had a previous myocardial infarction, and in 52 patients (28.4%), the stroke they had presented with was a recurrent stroke. One patient had a prosthetic cardiac valve, and one was already known to have AF. Both patients were on anticoagulation medication. At the time of admission with a stroke, both these patients had international normalised ratio values within the therapeutic range. All patients with previous myocardial infarction were on a single antiplatelet agent. No differences were found in the demographics of the patients who had presented with a first stroke or a recurrent stroke [Table 1].

As per the TOAST classification types, small vessel disease was the most common mechanism of stroke in this cohort, accounting for 112 (61.2%) patients. Large artery stroke was the mechanism in 56 (30.6%) patients, while in 15 (8.2%), the stroke was of undetermined aetiology. Cardioembolism, on its own, was not identified as a mechanism of stroke in any of these patients. The patients with AF had multiple atherosclerotic risk factors; therefore, their strokes were classified as having an undetermined aetiology. The middle cerebral artery was the most common artery to be affected (n = 44; 24.0%), followed by the posterior cerebral artery (n = 13; 7.1%). Almost a third of the patients (n = 67; 36.6%) had involvement of the left-sided limbs, while 45 (24.6%) had involvement of the right-sided limbs. Furthermore, in another 71 (38.8%) patients, the side of hemiplegia was not documented or no focal hemiplegia was found, as it was either symptoms of posterior circulation (such as dizziness and cerebellar signs), a lacunar infarct or the patient was comatose.

All the patients had undergone a resting 12-lead-ECG on arrival. This identified 14 patients to be

Table 3: Echo findings of included stroke patients

Finding	**n (%)**			***P* value***
	Overall group (N = 165)	**First stroke (n = 120)**	**Recurrent stroke (n = 45)**	
Ejection fraction in % ± SD	54.2 ± 11.1	54.8 ± 11.2	52.6 ± 10.7	0.23
LA size in mm (range)	25.7 (23.8–33.7)	26.86 (24–34)	25.0 (22.8–29.9)	0.07
LVIDd in mm ± SD†	4.2 ± 0.73	4.19 ± 0.72	4.13 ± 0.69	0.66
Aortic regurgitation				0.64
No/Mild	157 (85.7)	114 (95.0)	43 (95.5)	
Moderate	8 (4.4)	6 (5.0)	2 (4.4)	
Severe	0 (0.0)	0 (0.0)	0 (0.0)	
Aortic stenosis				0.68
No/Mild	161 (97.6)	117 (97.5)	44 (97.7)	
Moderate	1 (0.6)	1 (0.8)	0 (0.0)	
Severe	3 (1.8)	2 (1.7)	1 (2.3)	
Mitral stenosis				0.21
No/Mild	164 (99.4)	120 (100)	44 (97.7)	
Moderate	0 (0.0)	0 (0.0)	0 (0.0)	
Severe	1 (0.6)	0 (0.0)	1 (2.3)	
Mitral regurgitation				0.26
No/Mild	150 (90.9)	108 (90.0)	42 (93.3)	
Moderate	12 (7.3)	9 (7.5)	3 (6.7)	
Severe	3 (1.8)	3 (2.5)	0	
Pulmonary hypertension				0.20
No	144 (87.3)	101 (84.1)	43 (95.5)	
Mild	12 (7.3)	10 (8.3)	2 (4.4)	
Moderate	7 (4.2)	7 (5.8)	0	
Severe	2 (1.2)	2 (11.7)	0	
Agitated saline echo positive (n = 132)	10 (7.6)	6 (5.0)	4 (8.9)	0.38
Enlarged LA	24 (13.1)	21 (17.5)	3 (6.7)	0.08

SD = standard deviation; LA = left atrium; LVIDd = left ventricular internal diameter in diastole.
**Using Chi-squared test, students t-test or Mann-Whitney U test as appropriate. †Left atrium was considered to be enlarged if it measured >4 cm in men and >3.9 cm in women.*

in AF on presentation, with the rest being in sinus rhythm. All patients underwent a 24-hour Holter ECG monitoring. The 24-hour recording did not show any abnormality in 135 patients. AF was seen in 15 patients (one newly diagnosed in addition to the 14 who had AF on their resting ECG), 32 patients had evidence of non-sustained atrial arrhythmia, and nine had non-sustained ventricular tachycardia. A total of 30 patients were also noted to have frequent supraventricular ectopics (defined as >30/hour), while five patients had a high ventricular ectopic burden (>10% burden). No differences were observed between the findings of patients with a first or recurrent stroke [Table 2].

A total of 165 patients had an ECG performed during their stay at the hospital. There is no documented reason why the remaining 18 did not have an ECG. None of the patients had any mass, vegetation or thrombus noted in the scans. Severe aortic stenosis was identified in three patients, severe mitral stenosis in one patient and severe mitral regurgitation in three patients. Two were found to have severe pulmonary hypertension. Furthermore, 132 patients had an agitated saline contrast scan performed, of which

Table 4: Left atrial size and atrial arrhythmias

Finding	n (%)		*P* value*
	Normal LA size (n = 139)	Enlarged LA (n = 24)	
PAC burden			0.11
Low	113 (81.2)	15 (62.5)	
Medium	7 (5.1)	2 (8.3)	
High	19 (13.7)	7 (29.2)	
Atrial fibrillation	8 (5.7)	5 (20.8)	0.01
Atrial tachy-arrhythmias	24 (17.2)	5 (20.8)	0.1
PAC count (range)	6 (0–58)	33 (80–2,402)	0.06†

LA = left atrium; PAC = premature atrial contraction.
Values are number (percentage) or Median (interquartile range).
**Using Chi-squared test. †Using Mann-Whitney U test.*

10 were reported as positive for a left-to-right shunt (positivity rate of 7.7%). The RoPE score of these patients had a median of 5, with a range of 2–8. Three patients had a score of 6 and one of 8. A total of 24 patients had a left atrial size that was above the upper limits of normal (4 cm in males and 3.9 cm in females). No differences were found between patients presenting with a first or recurrent stroke [Table 3].

A higher proportion of patients having AF and atrial tachyarrhythmias was found in the group with enlarged left atria. Although numerically different, no statistical difference was observed in the PAC burden between the two groups [Table 4].

Discussion

The primary aim of cardiac investigations after a stroke is to identify any potential source of cardioembolism with the intention to treat and prevent the recurrence of strokes. These could be obvious thrombi or masses within the cardiac chambers, cardiac valve abnormalities or arrhythmias such as AF. Though the old stroke guidelines recommend routine testing in all patients with strokes, the current guidelines recommend routine imaging in the form of TTE and monitoring for rhythm disturbances, especially AF for patients with cryptogenic strokes. Similarly, while earlier guidelines recommend a minimum of 24 hours of ECG monitoring, subsequent studies have demonstrated that longer monitoring increases the detection rate of AF.[17,22,23] The latest guidelines have embraced this knowledge and recommend prolonged ECG monitoring of at least 48–72 hours or longer if possible.[24] None of the patients in the study had undergone prolonged monitoring. Besides the 14 patients who had AF on their resting ECG, 24-hour monitoring identified only one further patient.

In addition to episodes of AF, atrial ectopics or PAC has garnered interest as a precursor to AF. Studies have demonstrated conclusively that patients with a high burden of PACs have a higher risk of developing AF.[19,25] Binici *et al*. demonstrated that patients with a PAC rate of >30/hour had a 2.7-fold increase in the risk of developing AF and a >60% increased risk of death or stroke.[19] They found that for each increase of 10 PACs per hour, the risk of the primary end point of death or stroke increased by 27% and the risk of AF increased by 50%. While the American guidelines on stroke prevention do not specifically mention these statistics, it has been previously recommended that patients with a high PAC burden would benefit from anticoagulation, especially if their CHADS2VASC score is greater than 2. However, there are no studies available to support this recommendation. In the current study, 36 patients had some form of atrial arrhythmia, with a similar number having a high burden of PACs. Given the propensity of these patients to develop AF in the future and in the absence of facilities to perform long-term ECG monitoring, careful consideration should be paid regarding anticoagulation in the case of these patients.

The other abnormality commonly identified on Holter monitoring is frequent ventricular ectopics (VEs). These can predispose to impaired LV systolic function and the formation of LV thrombus that can embolise.[26] In the current study, almost a fifth of the patients had at least moderate-to-high burden of VEs. Although this can represent a high adrenergic stage in the immediate post-stroke state, such patients should be monitored for the development of tachycardia-related cardiomyopathy or other abnormalities.[26] Conduction abnormalities are commonly reported findings on Holter monitoring; however, in the current study, no patients with significant conduction abnormalities were detected.

Echocardiography can detect many potential cardiac sources of embolism, such as left atrial thrombus, PFO, atrial septum aneurysm, valvular or myocardial disease, vegetations or cardiac tumours.[27] Furthermore, it can reveal other cardiac pathologies of potential therapeutic consequences, such as wall motion abnormalities or reduced LV function. The mode of echocardiography can be either transthoracic—which is widely available, non-invasive, less personnel-intensive and cheap—or transoesophageal—which is otherwise superior for the evaluation of the aortic arch, left atrium and its appendage and atrial septum.[14]

Agitated saline contrast study is often considered part of the protocol for echocardiography in patients who have a stroke, with the aim of identifying any left-to-right shunts, notably PFOs. The role of closing a PFO post-stroke is still unclear with conflicting data. Earlier randomised controlled trials have failed to demonstrate a statistically significant benefit for PFO closure;[28,29] thus, many investigators believed that a PFO, being a not uncommon occurrence, was an incidental bystander in patients with stroke. However, meta-analyses and more recent specific trials have eliminated several confounding factors and possible biases and have demonstrated the benefit of the use of a shunt closure over medical therapy in patients with cryptogenic stroke, particularly among those <60 years with no obvious risk factors explaining the incident stroke.[30–32]

In the current study, 10 out of the 132 patients who had undergone an agitated saline contrast study were positive for a PFO. This is lower than the reported incidence of PFOs in the general population (20–30%) and the stroke population (approximately 50%).[33,34] This discrepancy could not be explained by the researchers. Except for one patient, all had a RoPE score of <7. The reason for the patient with a high RoPE score not being referred for further transesophageal echocardiogram assessment was not documented. It could be argued, therefore, that to be cost-effective, the agitated saline study should be performed only in cases with a high RoPE score.

The TTE may also identify other surrogate markers of potential AF, such as increased left atrial volume and left atrial strain. In addition, other anatomical variations that can favour the promotion of thrombi can also be diagnosed. These include an aneurysm of the interatrial septum (defined as a septal protrusion that is >11–15 mm and is often associated with PFOs), the persistence of eustachian valve (which directs fetal blood flow towards the PFO) and a prominent chiari network (persistence of a remnant of the foetal atrial development).[35–37] In the current study, the echo reports did not comment on the presence of any of these abnormalities in any of the patients. The other abnormalities that were diagnosed on TTE in the study were minor valve abnormalities. However, it is unlikely that this contributed to the stroke.

The overall yield of positive tests from routine cardiac investigations for all patients presenting with a stroke appears low in the current study. A total of 14 patients had newly diagnosed AF on their presenting ECG, with only one additional patient identified on 24-hour Holter monitoring. Echocardiography identified four cases with significant valve disease and a doubtful link to the presenting stroke. This is similar to other reported studies, where the diagnostic yield of routine testing was low and the cost-effectiveness of such routine tests was questioned.[38] However, upon including all the cases with surrogate markers of potential AF, such as high PAC burden and dilated left atria on echocardiography, the diagnostic yield for all directly and indirectly linked pathologies is higher. Additional studies are required to systematically ascertain whether anticoagulation in such patients carries any long-term benefits, especially as it relates to stroke prevention. Furthermore, it was observed that the results of the cardiac investigations (apart from those conducted on patients with AF) did not appreciably alter the final management, thereby bringing the usefulness of these investigations in all patients with a stroke into question. Indeed, the newer guidelines recommend these tests only in patients with cryptogenic strokes in contrast to the older guidelines, where these tests were recommended in all patients with a stroke, suggesting that the policy in the hospital be changed.

The current study has a few limitations. This was a retrospective study that involved examining past electronic case records of enrolled patients; the comprehensiveness of the case records, therefore, is a limiting factor as some patients had incomplete data and these were not included in the final diagnosis. The prognosis of these patients was not followed-up to check whether they had a recurrent stroke. Another limitation is that the left atrium size was measured in two-dimension, whereas, newer guidelines suggest that the left atrium area is to be calculated and adjusted to body surface area. This could have provided a more accurate account of the state of the left atrium.

Conclusion

The overall yield from cardiac investigations in patients presenting with a stroke is relatively low. They are, however, useful in identifying surrogate markers that increase the future risk of AF. However, studies are required to investigate the effectiveness of long-term anticoagulation in these patients. Further studies are also required to ascertain the cost-effectiveness of routine cardiovascular testing in all patients with a stroke and whether they influence management and outcome beyond identifying patients with AF.

Authors' Contribution

AA, IA and MA collected the data. SKN, ARG, HA and MAR analysed the data and drafted the manuscript. All authors approved the final version of the manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

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