National Thrombectomy Service

Annual Report 2021

OVERVIEW

Emergency endovascular thrombectomy (EVT: clot retrieval) is a procedure performed by interventional neuroradiologists to remove blood clots from an occluded intracranial vessel in patients with an acute large vessel occlusion stroke, restoring blood supply to the affected brain tissue. In Ireland, this is performed in Beaumont Hospital and Cork University Hospital (CUH).

According to international guidelines, based on high quality evidence, thrombectomy is the standard of care for patients with large vessel occlusion (LVO) leading to acute ischemic stroke up to 24hrs following the onset of symptoms, as long as the patients meet certain clinical and radiological criteria. Every patient with such a stroke should expect to have the opportunity to receive this treatment, with equality of access. It is estimated that up to 15% of ischaemic stroke patients would have an LVO potentially suitable for EVT. The remainder of strokes are due to smaller vessel occlusion, beyond reach of clot retrieval devices and require hyper-acute treatment with intravenous thrombolysis when suitable and acute stroke unit care for all.

In 2021, 514 patients were transferred for emergency thrombectomy (393 to Beaumont Hospital and 121 to CUH). 424 of these patients underwent thrombectomy (327 Beaumont Hospital, 97 CUH). In 2021 there were 4952 ischemic stroke discharges from public hospitals that refer patients to the National Thrombectomy Service in Beaumont Hospital/CUH, giving a thrombectomy rate of 8.5%. This is a slightly increased rate from 8.2% in 2020.

In 2021, 514 patients were transferred for emergency thrombectomy, Beaumont Hospital (393) and CUH (121). 8.5% of patients discharged with diagnosis of ischaemic stroke underwent thrombectomy

In 2021, the National Thrombectomy Service (NTS) in Ireland was provided by Beaumont Hospital and CUH. CUH switched to a 24/7 service in April 2021. All patients presented to their nearest acute hospital and were assessed clinically and radiologically, received thrombolysis if appropriate and if suitable, were transferred for thrombectomy following consultation with Beaumont Hospital/CUH. Patients within a 90 minute drive from Beaumont Hospital were repatriated immediately following treatment. Patients from further afield were admitted to Beaumont Hospital for 24hrs or more as clinically appropriate and then repatriated. All patients transferred to CUH were admitted for 24hrs or more prior to repatriation.

The NTS performs continuous data collection and service audit for quality improvement (registered with Beaumont Hospital Clinical Audit Department, CA210). The annual report is generated from this data.

The NTS measures time intervals in the patient care pathway between onset of symptoms and patient treatment. Time metrics are reflective of the efficiency of the emergency stroke service in individual primary stroke centres (PSCs).

In patients who underwent thrombectomy the median times for key steps are as follows:

- Time between onset** and arrival at PSC: 2hrs (n=213)
- Door* to CT time: 23 minutes (n=362)
- Door* to needle time (DTN): 43 minutes (n=132)
- Door* to EVT centre contact time: BH 55mins (n=239)/ CUH 56mins (n=26)
- Door in Door out** (DIDO): 1hr 40 mins (n=241) Patients referred to Beaumont Hospital only. (This time metric is not currently collected in CUH)
- Onset**to groin puncture: 4hrs 16mins (n=222)
- Onset** to reperfusion time: 4hrs 45mins (n=222)
- Onset*** to groin puncture: 9hrs 30mins (n=202)
- Onset*** to reperfusion time: 10hrs 6mins (n=197)

Please see a full breakdown of these time metrics per hospital below in the body of the report.

* Excludes inpatients at time of stroke.

**Witness onset only

***Unknown onset time (last seen well & wake up group).

Median door to needle times is 43 minutes nationally for all patients who underwent thrombectomy and also received thrombolysis.

DTN times are 43 minutes nationally for all patients who underwent thrombectomy. Thrombolysis is standard of care since 1996 and the benefit of early administration is well known. Data from the Helsinki Stroke Thrombolysis Registry have reported a reduction in the DTN times to 20 minutes in 2011. Centre volume has been shown to have a robust effect on DTN times with the shortest DTN times seen in centres with volumes of more than 100 patients treated with IVT per year (Strbian et al. 2015*).* In Stockholm in an LVO bypass system with pre-notification the DTN was 13 minutes in the endovascular centre.

The DIDO time is the time between arrival in the PSC and departure for Beaumont Hospital this reflects efficiency of acute stroke services in each centre and the ability of the ambulance service to provide rapid transfer. This remains stable at 1hr 40minutes for the 4th year.

THE NATIONAL QI PROGRAMME

The National QI Programme 'Door to Decision in 30' has continued with involvement of 20 of the hospitals acutely admitting stroke patients (except Naas General Hospital, Portiuncula, St. James Hospital & St Vincent's Hospital). In advance of the pandemic, hospitals agreed to continue the process. The programme suffered ongoing challenges throughout 2021 due to the Covid pandemic but in addition the HSE cyberattack impacted data collection greatly. However, teams continued to make their best efforts to collect the data reflecting the activities of their service, Roisin Walsh, QI Lead for stroke, was available to collate and analyse the data, to offer assistance and to tackle any particular issues related to QI which may have occurred from time to time within the acute stroke services. Throughout 2021 a few site visits were made (in between lockdown periods) and it was great to be able to interact with the teams face to face. In fact, although each hospital varied in their ability to continue to collect the data, in total we sustained the volume of patients for whom data was collected compared to previous years, and significant increases in the door to decision times were captured which is a remarkable achievement in itself.

LARGE VESSEL OCCLUSION (LVO) BYPASS UPDATE

In the last two annual reports I mentioned that consideration has been given to the development of a bypass protocol for patients in the Dublin region with severe, suspected LVO stroke, going directly to Beaumont Hospital. This is instead of the drip and ship model in which patients first go to another Dublin PSC for evaluation prior to transfer for thrombectomy.

In the Health Technology Assessment of Mechanical Thrombectomy for Stroke carried out by HIQA published in 2017, they recognised the need for organisational change and resource input in the stroke service to ensure equitable access to and benefit from mechanical thrombectomy, addressing regional variability.

Recommendation from NOCA/INAS from the National Report 2019 and 2020: "Pilot a large vessel occlusion ambulance bypass to the endovascular thrombectomy stroke centres in Dublin and Cork" This has not yet progressed.

In the 2019 report, INAS reported a difference in the time from onset of stroke to arrival at a thrombectomy centre between patients presenting directly to EVT centre versus those presenting initially to another PSC of 2hrs 27mins (1hr 33mins vs 4hrs). This resulted in a recommendation to establish a pilot LVO bypass protocol. The recommendation was made to the National Stroke Programme (NSP), facilitated by the Office of Chief Clinical Officer, HSE in conjunction with the NTS and National Ambulance Service (NAS). Reporting on 2020, INAS demonstrated a worsening in the differential between patients presenting directly to EVT centre versus those presenting initially to another PSC of 2hrs 51mins (1hr 34mins vs 4hrs 25mins). The recommendation to develop a pilot was repeated. I can report that in 2021 there has been no improvement in the differential time

between people with witnessed onset strokes arriving directly to Beaumont Hospital and those going to local PSC first (now a differential of 3hrs 9mins).

There has been no meaningful progress towards establishing a pilot bypass. The NTS governance group are fully supportive of the development of a bypass protocol, noting that it is essential also to maintain standards within the local PSC, so the majority of stroke patients, who are not suitable for bypass, will be appropriately managed in these centres. The Beaumont neuro-interventional and stroke teams are fully committed to this process. We have submitted a proposed pathway to the NSP but have been unable to gain traction with key stakeholders. The NAS has started work on the inclusion of the ACT FAST LVO identification scale. It is very discouraging to the Beaumont neuroradiology and stroke teams that there has not been any development in this recommendation from NOCA.

Such a bypass protocol is in place for acute coronary syndromes and works well. It is hard to imagine a patient with suspected heart attack going to a hospital that does not have coronary intervention and spending almost two hours there before being transported to one of the cardiac interventional centres. Stroke demands commensurate status as acute coronary syndrome – every minute counts. Infact, the effectiveness of thrombectomy for stroke more than matches the effectiveness of acute coronary intervention in cardiac ischemia.

I would like to take this opportunity to appeal to the NSP, The Office of Chief Clinical Officer and Beaumont Hospital Management to work together in conjunction with the NTS and NAS to develop a plan to get patients with severe stroke due to a LVO more rapidly to the point of endovascular treatment in Beaumont Hospital with a similar plan in place for CUH region. There are a large number of stroke team members and dedicated people who lead by example around the country, who work extremely hard to provide the best care possible for acute stroke patients and continue to be involved in our national QI programme optimising the acute care pathway. In order for us to maximise the potential of thrombectomy, we need to follow the path of cardiology and have a significant change in the way we provide the emergency thrombectomy service.

John Thornton
Director of National Thrombectomy Service

Annual Report 2021 Overview

Emergency endovascular thrombectomy (EVT) is considered standard of care for up to 24hrs following the onset of acute ischaemic stroke. In Ireland, this procedure is carried out in two thrombectomy centers, Beaumont Hospital and Cork University Hospital. In 2021, of the 4952 patients discharged with acute ischaemic stroke, 424 patients underwent thrombectomy (8.5%)

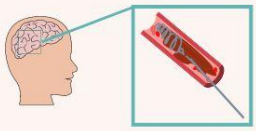
Time matters

"Time is Brain" *every minute saved from onset of symptoms to treatment restores one week of healthy life (Meretoja et al, 2017)*

"Every second counts" *from hospital arrival to EVT start, every 1 second of delay was associated with the loss of 2.2 hours of healthy life (Almekhlafi et al, 2021)*

Thrombectomy - Standard of Care

Emergency endovascular thrombectomy is a procedure performed by interventional neuroradiologists for treating acute ischaemic stroke. It involves mechanically removing the obstructing blood clot from arteries within the brain, restoring blood flow and minimising permanent tissue damage *(NICE, 2018)*
Thrombectomy is standard of care for patients with acute large vessel occlusion stroke as per multiple international guidelines. Studies show that only 26% of patients would recover without thrombectomy versus 46% with *(HERMES Collaboration, 2016)*



424 Thrombectomies

In 2021, 424 patients underwent emergency thrombectomy, 327 at Beaumont Hospital and 97 at Cork University Hospital.

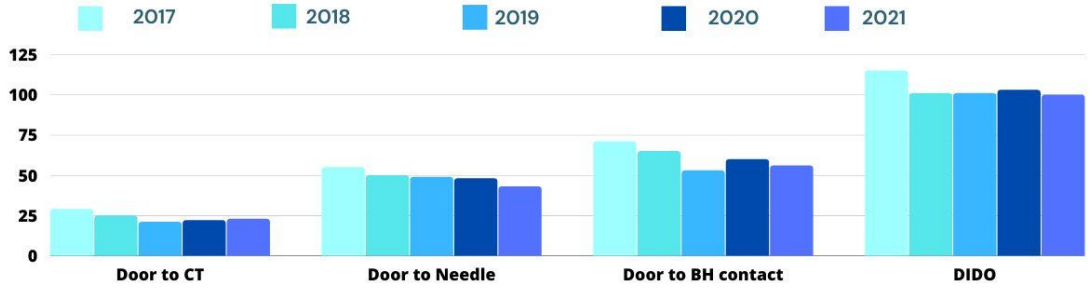
Onset to Reperfusion 4hr 45mins

Inpatients with a witnessed onset stroke, had a median time from onset of symptoms to establishment of reperfusion of 4hrs 45mins in patients undergoing thrombectomy in 2021

48% Functional Independence

48% of patients had a modified Rankin Score of 0-2 indicating achievement of full functional independence after thrombectomy.

Median Values for Thrombectomy patients At Beaumont Hospital



23 mins Door to CT

Median time from arrival at hospital to CT Brain was 23 mins for patients undergoing thrombectomy.

43 mins Door to Needle Time

Median time from arrival at hospital to receiving IV thrombolysis was 43 mins for patients undergoing thrombectomy. An improvement of 5 mins from 2020

55 mins Door to EVT Referral

Median time from arrival in hospital to contacting the EVT centre to make a decision about transfer for thrombectomy was 55mins to Beaumont and 56mins to CUH.

DIDO All EVT pts: 100 mins → DIDO All PitStop pts: 75 mins

Door In Door Out for EVT pts = 100mins
PitStop DIDO = 75mins

Median time from arrival in PSC to departure for Beaumont was 100mins. A project between Naas & Beaumont (PitStop) saw a reduction to 45mins. This protocol is now extended to Tallaght and Mullingar Hospitals, who in 2021 had a DIDO time of 75mins (n34) .

For more information please contact The National Thrombectomy Service

CONTENTS

INTRODUCTION

Emergency thrombectomy is considered standard care for up to 24 hours following the onset of acute ischemic stroke following multiple RCT's. Based on this evidence, our inclusion criteria for thrombectomy includes all patients with LVO within 24 hours of onset of symptoms, with ASPECTS of ≥5 and good (>50%) collateral circulation on multiphase CTA. We employ a drip-and-ship model for the transfer of patients for thrombectomy, and in most cases a drip, ship, retrieve and leave model for those patients coming from hospitals within a 90 min drive - meaning immediate repatriation to the PSC by the awaiting ambulance crew and accompanying medical team.

The National Thrombectomy Service Governance Group has developed a pathway for the transfer of patients for thrombectomy. The group meets quarterly to discuss the service, monitor activity and consider future development.

DESCRIPTION OF AUDIT PROCESS FOR ANNUAL REPORT

A prospective database is maintained for suspected stroke patients who are admitted to any of the PSCs. Patients are evaluated clinically and radiologically and if deemed suitable for endovascular thrombectomy are transferred to Beaumont Hospital/CUH. We collect information about all patients admitted with suspected acute stroke (FAST Positive). The majority of these will not require any consultation with thrombectomy centres at Beaumont Hospital/CUH. These patients are picked up in the national QI program. For others, there is a phone conversation with Beaumont Hospital/CUH and the patient may or may not be transferred. Once transferred most patients undergo thrombectomy but some become unsuitable for treatment. Data concerning patients are entered into the thrombectomy database, an electronic purpose built database designed by the National Thrombectomy Service (NTS) and Beaumont ITC department. All data for this 2021 annual report has been extracted from the NTS/stroke database which is housed on the Beaumont Hospital network.

CUH have a separate database (excel based) for their cohort of patients. Their data is sent to the thrombectomy service team in Beaumont to analyse and collate which gives an overall review of data nationally for those presenting to the two endovascular centres in Ireland. The vision that we are working towards is having one national thrombectomy database.

OVERVIEW OF DATASETS

FAST POSITIVE (SUSPECTED STROKE PATIENTS) DATASET

Through the National Thrombectomy Service QI programme, data is captured by local stroke teams on any patients who present to any stroke centre with symptoms suggestive of acute stroke.

Data points include:

- Onset date/time

- Arrival date/time at PSC
- Time of CTB/CTA/CTP
- IV lysis time
- If EVT centre was contacted
- Time EVT centre contacted
- Time of decision re thrombectomy (regardless of whether or not EVT centre was contacted, or if the decision is not for thrombectomy).
- Departure time if transferred for thrombectomy.
- Final diagnosis

The decision time regarding need for thrombectomy is applicable to all patients. A yes/no decision reflects how long an ambulance crew would need to wait before being released, or completing the transfer of the patient to Beaumont Hospital or CUH.

This data is used for QI purposes to assess the performance of each stroke service and forms the basis for identifying service quality improvements required (see below for further discussion). The ability of each team to capture this information varies from hospital to hospital. There is overlap of this data with the dataset below and the outcomes are presented separately in this report.

REFERRALS DATASET

Previously, once a call was made to Beaumont Hospital thrombectomy service regarding possibility of thrombectomy, we recorded a minimum dataset as per QI dataset. As the volume of cases collected in each hospital for QI programme has increased we no longer keep this dataset, reducing duplication. We recognise however, that not all hospitals keep the full FAST positive database and some patients are not captured.

PATIENTS TRANSFERRED TO THE THROMBECTOMY CENTRE BUT UNSUITABLE FOR EVT DATASET

On arrival at Beaumont Hospital from PSC for thrombectomy patients are re-evaluated. Generally if >2hrs since original imaging, this is repeated. Some patients are found to be unsuitable for treatment due to a number of reasons (various reasons for unsuitability are noted in table 14 below). Avoiding unnecessary transfers and improving efficiency of transfer are targeted with this information.

THROMBECTOMY PATIENT DATASET

The most extensive and largest data set is of the patients who proceed to thrombectomy. There are approximately 65 data points on each patient, allowing detailed analysis of the service from onset of stroke to point of recanalisation and final clinical outcome at 90 days. This is the only national dataset which measures stroke outcomes at 90 days.

Patients who are transferred for thrombectomy are presented and discussed at the monthly stroke MDM held in Beaumont Hospital. WebEx video conferencing system allows referring sites to join this meeting remotely and have an input into the discussion regarding their patients. Each PSC receives an email with a list of their patients who are on the list for discussion at these meetings. They also receive a feedback form for each patient who is transferred; this gives a summary of their time metrics and procedure/clinical outcomes.

Clinical follow up for patients post thrombectomy is given to us by the stroke CNS in each hospital. Our audit approval includes capturing the final outcome data and going forward we are collecting enough patient demographics to facilitate direct contact with patients/families to assess outcome if this is not otherwise available.

For this annual report, we analyse the above datasets. Data quality is checked by reviewing patient entries soon after input and again in preparation for the report. Outlying metrics are reviewed for accuracy of data. Imaging pre and post procedure, the procedure details and images including final revascularisation scores are reviewed by neuroradiology SPRs and consultants so that each study is reviewed by a different neuroradiologist to the one who performed the procedure.

QI data is collected by individual hospitals and sent to QI lead Roisin Walsh. The data is collated and fed back to stroke teams intermittently through the year. Each team has had an opportunity to review their end of year data prior to submission in the annual report.

Completion of the report can only occur after the 90 day follow up assessments and the number of stroke discharges from all hospitals are available from HIPE (this year the HIPE dataset was available at the middle of June). This report is compiled by members of the thrombectomy/stroke service team in Beaumont Hospital.

RESULTS

According to HIPE data, 4952 patients were discharged with primary diagnosis of cerebral infarctions in 2021 (i63 & i64) from hospitals with acute stroke services. 393 patients were transferred to Beaumont Hospital with a view to thrombectomy & 327 underwent thrombectomy, including 43 patients who presented directly to Beaumont Hospital. 66 patients were transferred but did not undergo thrombectomy as they were deemed unsuitable after clinical evaluation, repeat imaging or following catheter angiogram on arrival.

Furthermore, there were 121 patients transferred to CUH with a view to thrombectomy and 97 underwent thrombectomy, including 55 patients who presented directly to CUH. 24 patients were transferred but did not undergo thrombectomy.

THROMBECTOMY PATIENT DEMOGRAPICS (N=424)

- Male: 229 (54%)
- Female: 195(46%)

Median Age: 73 (15-98)

≤65 years: 135 (32%)

>65 years: 289 (68%)

NIHSS & ASPECTS PRE EVT

Pre NIHSS (median): 14 (1-34)

Pre ASPECTS (median): 9 (4-10)

VESSEL OCCLUSION SITES

58(14%) patients had more than 1 vessel occlusion site or had additional significant carotid stenosis.

Table 1: Occlusion sites

Occlusion site	2021 N (%)
M1	193 (46)
M2 proximal	92 (22)
ICA cervical	53 (12)
Carotid T	21 (5)
Basilar	22 (5)
M2 distal+	14 (3)
ICA tandem stenosis	7(2)
ACA:	9 (2)
Vertebral	6(1)
PCA	7(2)

The total thrombectomy rate for 2021 was 424/4952 (8.5%). In 2020 the rate was 391/4764 (8.2%). 8/25 hospitals increased their rate of referral.

Table 2: Thrombectomy Rate 2021 vs 2020, 2019 & 2018

Hospital	2021 Referral N (%)	2021 Total N Of Ischaemic Strokes	2020 Referral N (%)	2019 Referral N (%)	2018 Referral N (%)
Beaumont	43 (14)	307*	50 (12)	40 (13)	41 (19)
Mater Misericordiae University Hospital	37 (14)	262	44 (17)	47 (15)	36 (11)
St. James Hospital	18 (8)	235	22 (10)	23 (10)	26 (11)
Naas General Hospital	17 (10)	178	12 (7)	19 (10)	19 (11)
Mullingar Regional Hospital	27 (18)	148	16 (12)	11 (10)	9 (9)
St. Lukes Hospital Kilkenny	9 (8)	117	11 (9)	9 (9)	7 (7)
Tallaght University Hospital	32 (12)	273	18 (7)	21 (10)	17 (7)
OLOL	20 (8)	244	14 (6)	17 (9)	11 (6)
CUH	55 (13)	431*	59 (14)	43 (10)	37 (9)
SVUH	39 (10)	395	34 (10)	28 (8)	19 (5)
Letterkenny General Hospital	7 (4)	168	2 (1)	6 (4)	5 (3)
Cavan General Hospital	17 (11)	147	4 (3)	4 (4)	2 (1)
University Hospital Waterford	7 (5)	141	7 (5)	14 (9)	9 (8)
University Hospital Limerick	22 (7)	329	31 (8)	13 (5)	16 (5)
Connolly Hospital Blanchardstown	5 (2)	213	4 (2)	5 (3)	7 (4)
Sligo General Hospital	11 (5)	202	5 (3)	6 (4)	10 (6)
Mayo University Hospital	6 (4)	138	9 (5)	11 (6)	8 (6)
Galway University Hospital	19 (7)	262	24 (11)	21 (8)	14 (5)
Wexford General Hospital	13 (8)	160	10 (10)	10 (9)	3 (2)
Midland Regional Hospital Tullamore	1 (N/A)	110	1 (1)	2(3)	1(1)
University Hospital Kerry	6(4)	131	3 (2)	11 (9)	2 (1)
South Tipperary General Hospital	2 (2)	102	3 (4)	6 (6)	4 (4)
Portiuncula University Hospital	0	0	0	2 (4)	0 (0)
Mercy University Hospital	2(2)	99	3 (4)	7 (9)	2 (2)
Bantry General Hospital	3 (5)	64	2 (3)	2 (2)	1 (1)
South Infirmary Victoria Hospital	1	N/A	N/A	N/A	N/A
Belfast	N/A	N/A	1	N/A	N/A

Private Hospitals (Bons, SVUH Pri, BRC)	3	N/A	N/A	N/A	N/A
National Maternity Hospital	1	N/A	N/A	N/A	N/A
TOTAL	**424**	**4952**	**392**	**384**	**317**

*This number excludes external referrals; it reflects no. of patients admitted directly to Beaumont Hospital or CUH

TIME METRICS

Table 3: Door metrics of patients who underwent thrombectomy procedures at Beaumont Hospital. The inpatients who have stroke are not included in these calculations

Hospital	Total N 2021 (IP)	Door To CT Median (Hr:Min) {Range}	Door To Needle Median (Hr:Min) {Range}	Door To BH Contact Median (Hr:Min) {Range}	DIDO Median (Hr:Min) {Range}
Beaumont Hospital	43 (7)	00:18↓2min {00:05-01:28} IQR{00:14-00:27}	00:27(n=16) ↓16min {00:08-01:08} IQR{00:25-00:37}	N/A	N/A
Cavan	17 (0)	00:45 ↑19mins {00:09–01:54} IQR{00:31-01:08}	01:57(n=6) ↑51mins {01:10-03:30} IQR{01:20:02:21}	01:58 ↑55mins {00:40-02:40} IQR{01:14-02:18}	02:40 ↑9mins {01:20-05:23} IQR{02:08-03:26}
Connolly	5 (2)	00:15↓11mins {00:12-00:25}	01:00↑24mins (n=1)	00:35 ↓9mins {00:33-00:35}	01:10 ↓13mins {00:54-01:45}
Galway	19(3) {↓5}	00:24↑1min {00:06-00:48} IQR{00:16-00:28}	00:52(n=4) ↑18mins {00:30-02:28} IQR{00:34-01:46}	00:55 ↓1min {00:14-01:40} IQR{00:38-01:10}	01:57 ↓8mins {00:51-03:25} IQR{01:42-02:30}
Kilkenny	9(3) {↓2}	00:16 ↓10mins {00:07-00:41} IQR{00:08-00:30}	00:27(n=3) ↓15 (00:20-00:31)	00: 40↓14mins {00:27-01:10} IQR{00:32-00:58}	01:31 ↓1mins {00:57-01:45} IQR{01:04-01:38}
Letterkenny	7 (3) {↑5}	00:29 ↑6mins {00:10-00:39} IQR{00:16-00:37}	00:17(n=3) {00:16-00:35}	01:13 ↓1min {00:33-01:37} IQR{00:44-01:34}	02:07 ↓23mins {01:03-03:10} IQR{01:16-02:57}
Limerick	1 (0)	00:15 (n=1)	00:31 (n=1)	00:35 (n=1)	01:56 (n=1)
Mater	31 (6) {↓13}	00:23 ↑6mins {00:04-02:57} IQR{00:13-00:29}	00:50(n=10) ↑6mins {00:25-01:45} IQR{00:35-01:00}	00:43 ↓8mins {00:12-05:36} IQR{00:31-01:01}	01:24 ↔ {00:35-07:00} IQR{00:56-01:39}
Mayo	6 (0) {↓3}	00:48 ↑2mins {00:42-01:36} IQR{00:44-01:00}	01:41(n=2) ↑25mins {01:20-02:00}	01:37 ↓4mins {00:59-02:24} IQR{01:30-02:20}	03:13 ↑48mins {02:15-04:14} IQR{02:17-03:50}
Mullingar	27(3) {↑11}	00:23 ↓7mins {00:10-00:50} IQR{00:17-00:29}	01:02(n=8) ↑14mins {00:36 – 01:47} IQR{00:44-01:13}	00:56 ↓36mins {00:17-02:12} IQR{00:40-01:14}	01:27 ↓33mins {00:25-04:13} IQR{01:06-02:00}

Naas	17 (3) {↑5}	00:19 ↑2mins {00:04-04:40} IQR{00:13-00:40}	00:43(n=7) ↑8mins {00:34-01:00} IQR{00:40-00:55}	00:41 ↓4mins {00:23-05:22} IQR{00:35-00:51}	00:59 ↓1min {00:33-06:36} IQR{00:45-01:15}
OLOL	20(2) {↑6}	00:18 ↔ {00:06-00:35} IQR{00:14-00:23}	00:42(n=9)↓12mins {00:28-01:20} IQR{00:29-01:00}	00:59 ↑1min {00:25-02:30} IQR{00:48-01:15}	01:54 ↑11mins 00:45-03:15} IQR{01:28-02:15}
Sligo	11 (1) {↑6}	00:29 ↑15mins {00:12-00:41} IQR{00:27-00:32}	00:45(n=4) ↑12mins {00:40-00:50} IQR{00:42-00:49}	00:55 ↑15mins {00:35-01:46} IQR{00:42-01:16}	02:07 ↑44mins {01:34-03:26} IQR{01:40-02:42}
St James	18 (2) {↓4}	00:36 ↑8mins {00:15-09:30} IQR{00:23-00:52}	01:02(n=10) ↓21mins {00:20-02:23} IQR{00:55-01:20}	01:09 ↑7mins {00:30-11:30} IQR{00:47-01:27}	02:06 ↑31mins {01:07-12:55} IQR{01:39-02:34}
SVUH	39 (3) {↑5}	00:20 ↓7mins {00:05-04:42} IQR{0012:-00:30}	00:43(n=12) ↓7mins {00:14-02:44} IQR{00:25-01:06}	00:45 ↓12mins {00:24-06:05} IQR{00:35-01:26}	01:31 ↓2mins {00:40-07:25} IQR{01:08-02:11}
Tallaght	32(5) {↑14}	00:19 ↑1min {00:06-03:21} IQR{00:14-00:30}	00:36(n=12) ↓3mins {00:20-03:55} IQR{00:25-00:53}	00:52 ↑9mins {00:15-04:05} IQR{00:28-01:04}	01:28 ↑9mins {00:44-04:50} IQR{01:10-01:55}
Tullamore	1 (1)	N/A	N/A	N/A	N/A
Wexford	13 (1) {↑3}	00:54 ↑9mins {00:29-01:34} IQR{00:35-01:16}	01:03(n=6)↑11mins {00:38-01:30} IQR{00:45-01:20}	01:50 ↑37mins {00:55-02:30} IQR{01:17-02:02}	02:58↑56mins {02:03-05:38} IQR{02:27-03:22}
Private Hospitals	5 (5)	N/A	N/A	N/A	N/A
TOTAL	**327 (50)**	**00:23** ↑1min **(n=277) {00:04-09:30}** IQR{00:15-00:36}	**00:42**↓6min **(n=114) {00:08-03:55}** IQR{00:31-01:05}	**55:00** ↓5mins **{00:12-11:30} (n=239*)** IQR{00:39-01:25}	**01:40** ↓3mins **{00:25-12:55} (n=241)** IQR{01:13-02:21}

NB: Hospitals with <4 referrals do not have an IQR.

*Missing contact times on 2 patients

Figure 1: Median values for thrombectomy patients at Beaumont Hospital

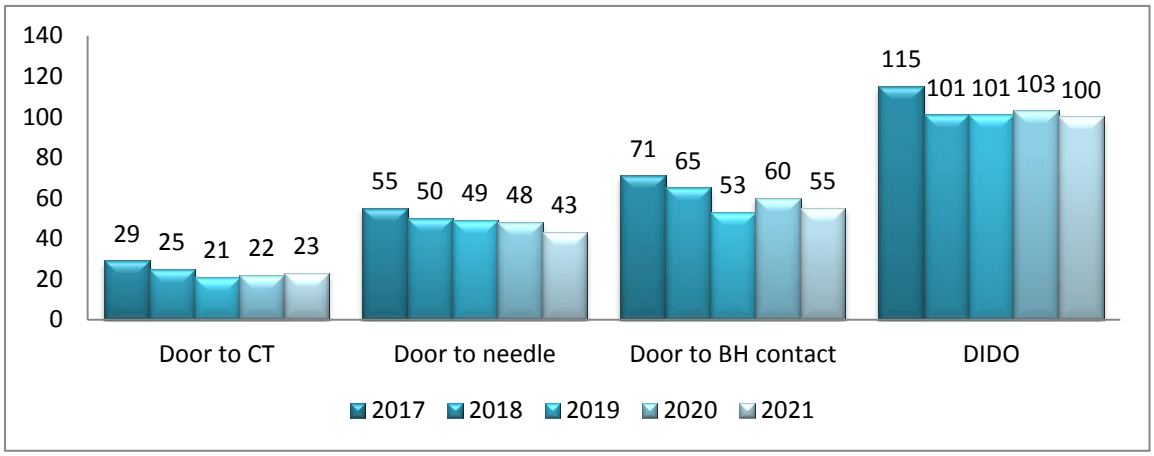


Table 4: Door metrics of patients who underwent thrombectomy procedures at Cork University Hospital

Hospital	Total (IP)	Door To CT Median {Range}	Door To Needle Median {Range}	Door To CUH Contact Median {Range}
Cork University Hospital	55 (7){↓4)	00:22 ↓7mins {00:04–03:56} IQR{00:16-00:27}	00:38 ↑8mins (n=4) {00:25–01:06} IQR{00:26-00:57]	N/A
Bantry General Hospital	3 {↑1}	00:28↓33mins {00:05–00:29}	N/A	01:00 {00:14–02:07}
University Hospital Kerry	6 {↑3}	00:40 ↑20mins {00:12–13:04} IQR{00:16-01:11}	01:09 ↑14mins (n=1)	01:45 (N5) ↑9mins {00:55–12:41}
Mercy University Hospital	2 (1) {↓1}	00:03 ↓12mins (n=1)	00:38 ↑23mins (n=1)	23mins (n=1)
South Tipperary General Hospital	2 {↑1}	00:16 ↓14mins	33mins (n=1)	00:47 (n1) ↑4mins
South Infirmary Victoria University Hospital	1 (1)	N/A	N/A	N/A
University Hospital Limerick	21 {↑8}	00:25 ↓18mins {00:13–03:28} IQR{00:16-00:45}	00:45 ↓7mins (n=10) {00:21–02:11} IQR{00:43-00:54}	00:52 ↓3mins (n=12) {00:40–03:47} IQR{00:46-01:35}
University Hospital Waterford	7 (1) {↑3}	00:31 ↑5mins {00:14–03:58} IQR{00:24-00:38}	00:40 ↑17mins (n=3) {00:37–00:45}	00:58 ↓10mins (n=3) {00:43–01:05}
Total	**97 (10)**	**00:23 ↓7mins (n=86*) {00:03–13:05}** IQR{00:16-00:36}	**00:43↑1min (n=20**) {00:21–02:11}** IQR{00:37-00:52}	**00:56↓3mins (n=26***) {00:14–12:45}** IQR{00:45-01:45}

NB: Hospitals with <4 referrals do not have an IQR

*Missing one door time on patient transferred to CUH from Limerick

**Missing IV lysis times on 2 patients

***Missing contact times on 16 patients

Door to CT and DTN times reflect internal hospital processes related to early patient clinical and radiological evaluation with a view to intravenous thrombolysis which is standard of care for over 20 years, following the pivotal NINDS trial in 1995. The American Heart Association guidelines recommend DTN times of less than 60 mins, aiming for less than 45 mins. The most efficient hospitals in the world achieve DTN times of approximately 15mins. Every minute counts. Save a minute, save a week!!

The median door to CT is 23mins and the door to needle is 43mins (n=134) for patients receiving thrombectomy in BH and CUH.

The overall IV lysis rate for patients referred to Beaumont & CUH thrombectomy centres and underwent EVT in 2021 was 32% (n=134). In CUH this is 21% and in BH catchment this is 32%. Previously, we captured this for Beaumont Hospital only and the metrics were 43% (n=131) in 2020, 42% (n=130) in 2019, 50% (n=131) in 2018 and 52% (n=130) in 2017. IVT remains the standard of care for all eligible patients with large vessel occlusion, in addition to thrombectomy. It is noteworthy that the absolute number of IVT cases has not increased since 2017.

TENECTEPLASE

Alteplase has been the standard of care thrombolytic agent for acute ischaemic stroke following pivotal NINDS and ECASS III randomised controlled trials (RCTs) in 1995 and 2008 respectively. Tenecteplase is a genetically modified tissue plasminogen activator with higher fibrin specificity, a longer half-life and reduced binding to PAI-1 (plasminogen activator inhibitor 1), which leads to greater resistance to inactivation by PAI-1, compared to alteplase. Thus, tenecteplase could potentially be associated with greater recanalization and lower bleeding risk than alteplase. It is given as a single intravenous bolus without the need for an infusion offering further pragmatic advantages.

The evidence base for tenecteplase in acute ischaemic stroke (AIS) is growing, with several completed RCTs and meta-analyses to date demonstrating non-inferior safety and efficacy relative to alteplase and possible superiority for early recanalization. Several more RCTs are ongoing. The current body of trial evidence and many international stroke guidelines support the potential for tenecteplase as an option for stroke thrombolysis.

The COVID 19 pandemic posed many challenges for acute stroke care. FAST call assessment is a particularly vulnerable situation for exposure and transmission and reducing the time and intensity of interactions with individuals with known or suspected COVID 19 was of paramount importance. Beaumont Hospital treats the largest volume of patients in the country with intravenous thrombolysis (54 in 2020). Given the additional challenges with COVID and the simplified workflow with tenecteplase and potential to reduce the risk of exposure to and transmission of COVID 19 virus during acute stroke emergency assessment and treatment, the Beaumont Stroke Team, in agreement with the Pharmacy Department and Drugs and Therapeutics Committee, changed the thrombolytic agent used for hyperacute stroke management from alteplase to tenecteplase in June 2020. This was a smooth and hugely successful transition. Feedback from all members of the stroke team was positive with all preferring the pragmatic advantages of single bolus administration rather than need for one hour infusion. In 2021 there was a worldwide shortage of tenecteplase and Beaumont had to temporarily revert back to alteplase in July 2021. This felt like a retrograde step and thankfully tenecteplase supply was re-established in October 2021.

It is anticipated that the use of tenecteplase in stroke thrombolysis will increase as more data accumulates demonstrating safety and efficacy with potentially improved vessel recanalization and faster door to needle times.

In 2021 the median door to Beaumont Hospital contact is 55mins and the DIDO time is 1 hour 40 mins.

The interval between CT and Beaumont Hospital contact remains too long and could be significantly shortened by improved communication between radiology and the referring physician. We have seen that this is improved in hospitals using software Apps facilitating immediate transfer of imaging and an automated interpretation to the phone of relevant personnel. Additional complexity arises when outsourcing to on-call radiology services occurs. Discussion is required with such providers to ensure priority reporting for acute stroke imaging.

Door to contacting Beaumont Hospital times as well as DIDO times reflect the ability to process patients for a decision about thrombectomy and get them transferred. This is due to a combination of internal processes and the time taken to get an ambulance transfer.

If the door to contact time was <30 mins the ambulance crews could be asked to wait and bring the patient immediately potentially achieving a DIDO of 30-40 mins.

HOSPITAL RANKINGS

The rate of thrombectomy nationally based of ischaemic stroke discharges per HIPE is 8.5%. This year only hospitals with a referral of ≥5 patients will be ranked in table below. Eight hospitals had a rate of referral for thrombectomy of more than 8.5% and 12 hospitals referred less than 8.5%. To rank the time metrics for these hospitals reflecting their efficiency, we have split them into two groups for more appropriate comparison. This data includes referrals to both Beaumont Hospital and Cork University Hospital. Three of the top four hospitals ranked for DIDO are using PITSTOP protocol. Hospitals with 5 or less in each category were not included in the rankings.

Table 5: Hospital rankings where referral rate >8.5%

Hospital	Referral Rate	DTCT	DTN	Door to contact	DIDO
Midland Regional Hospital Mullingar	18%	6	2	5	3
Mater	14%	6	7	2	2
Cork University Hospital	13%	5	4	N/A	N/A

Tallaght University Hospital	12%	2	2	4	4
Beaumont Hospital	14%	1	1	N/A	N/A
Cavan General Hospital	11%	8	8	6	6
SVUH	10%	4	5	3	5
Naas	10%	2	5	1	1

Table 6: Hospital where referral rate ≤8.5%

Hospital	Referral Rate	DTCT	DTN	Door to contact	DIDO
Wexford	8%	10	4	9	6
Our Lady of Lourdes Drogheda	8%	2	1	5	2
St. Lukes Hospital Kilkenny	8%	1	Doesn't meet target to rank as n=<5	1	1
St James'	8%	7	3	6	4
Galway University Hospital	7%	3	Doesn't meet target to rank as n=<5	4	3
University Hospital Limerick	7%	4	2	2	This metric was not collected in CUH
Bantry General Hospital	5%	Doesn't meet target to rank as n=<5	Doesn't meet target to rank as n=<5	Doesn't meet target to rank as n=<5	This metric was not collected in CUH
Sligo University Hospital	5%	5	Doesn't meet target to rank as n=<5	3	5
University Hospital Waterford	5%	6	Doesn't meet target to rank as n=<5	Doesn't meet target to rank as n=<5	This metric was not collected in CUH
University Hospital Kerry	4%	8	Doesn't meet target to rank as n=<5	8	This metric was not collected in CUH
Mayo General Hospital	4%	9	Doesn't meet target to rank as n=<5	7	7
Letterkenny General Hospital	4%	Doesn't meet target to rank as n=<5	Doesn't meet target to rank as n=<5	Doesn't meet target to rank as n=<5	Doesn't meet target to rank as n=<5

Mercy University Hospital	2%	Doesn't meet target to rank as n=<5	Doesn't meet target to rank as n=<5	Doesn't meet target to rank as n=<5	This metric was not collected in CUH
South Tipperary General Hospital	2%	Doesn't meet target to rank as n=<5	Doesn't meet target to rank as n=<5	Doesn't meet target to rank as n=<5	This metric was not collected in CUH
Connolly Hospital	2%	Doesn't meet target to rank as n=<5	Doesn't meet target to rank as n=<5	Doesn't meet target to rank as n=<5	Doesn't meet target to rank as n=<5

The fastest DTN time in the Beaumont Hospital group* was recorded in Beaumont Hospital at 8mins, Beaumont Hospital also have the shortest median DTN at 27mins (n=16).

The fastest DTN time in the CUH group* was recorded in University Hospital Limerick at 21mins. University Hospital Limerick also have the shortest median DTN time at 45mins (n=10).

In the overall group, the most improved median DTN time was in St. James Hospital with a 21mins improvement to a median of 1hr 2mins (n=10).

**included in this group are hospitals who thrombolysed ≥5 patients.*

DOOR TO GROIN PUNCTURE

Time from arrival in Beaumont Hospital & CUH to groin puncture reflects efficiency in interventional radiology and stroke services, as each time interval affects patient outcome. In-patient strokes are excluded. The analysis of this has been done (table 8) separately for those presenting directly to Beaumont Hospital & CUH and for those on a Drip & Ship model transferred from elsewhere versus direct presentation to Beaumont Hospital and CUH.

Table 7: Time from arrival to groin puncture

Beaumont Door to Groin (n=36) {↓7}	00:52 ↓1min
Drip & Ship Model (n=284) {↑28}	00:15 ↔
Cork University Hospital Door to Groin (n=47) {↓3}	01:32 ↓2mins
Drip & Ship Model (n=41) {↑21}	00:44 ↑3mins

Table 8: Time metrics for thrombectomy procedures carried out in Beaumont Hospital

Median length of procedure	00:29 ↑1min
Median time groin puncture to 1st reperfusion (n=317)	00:20 ↑1min

Table 9: Time metrics for thrombectomy procedures carried out in Cork University Hospital

Median length of procedure	00:40 ↓7mins
Median time groin puncture to 1st reperfusion (n=89)	00:25 ↑2mins

Outcomes

TICI RECANALISATION

TICI recanalisation reflects the technical success of the Thrombectomy procedure for anterior circulation strokes only. Rates of 2b, 2c & 3 are considered good and expected rates internationally are 80% for 2b-3 inclusive. Thrombectomy can be performed using aspiration technique or stentriever. Randomised trials have shown equivalence. We have published our experience using a standardised aspiration first approach which in our experience gives better recanalisation in a shorter time. Evidence also suggests that the fewer passes performed, the better the likely clinical outcome. First pass effect is a measure of the success of recanalisation after a single pass.

In 2021 we achieved TICI 2b or better in 96% in anterior circulation strokes.

Techniques Used*

1st pass aspiration device: n=261

1st pass stentriever: n= 62

Single pass only: n= 315

*Excludes CUH procedural techniques (n=97)

Table 10: First pass TICI Recanalisation rates

TICI Scores post 1st pass	2021 N (%)
2c-3:	121 (42)
2b:	65(22)
2a:	50(17)
0-1:	57(19)

Table 11: Final TICI recanalisation rates

TICI Post Scores 2021	2021 N (%)	2020 N (%)	2019 N (%)	2018 N (%)
2c-3:	189 (64)	192 (66)	183 (63)	182 (73)
2b:	93 (32)	74 (25)	68 (24)	46 (19
2a:	9 (3)	11(4)	25 (7)	12 (5)
0-1	4 (1)	14 (5)	12 (6)	6 (3)

The above 2021 TICI scores do not include the posterior circulation and basilar occlusions (n=16) all of which had good recanalisation rates, as they do not have the same scoring system.

THE NIH STROKE SCALE

The NIH Stroke Scale (NIHSS) measures stroke related neurologic deficit. This assessment is carried out when a patient presents to their PSC with stroke symptoms, before patients proceeds to endovascular thrombectomy, at 24hrs & Day 5 post endovascular thrombectomy. When measured at 24hrs a score of ≤8 is highly predictive of long term functional outcome for anterior circulation stroke (Meyer *et al.,* 2020).

In 2021, 24hr NIHSS of ≤8 was achieved in 50%.

The median 24hr NIHSS was 6 (n=394).

MODIFIED RANKIN SCALE

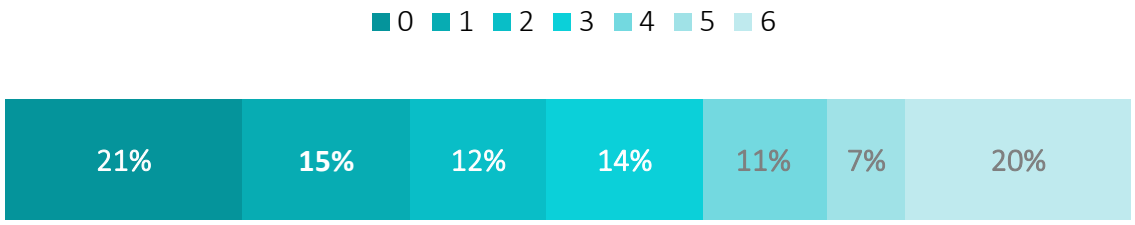
The Modified Rankin Score (mRS) is a 6 point scale reflecting the level of disability/dependence in daily activities of people who have suffered a stroke. 90 day mRS indicates the 90 day clinical outcome and is an international standard in stroke literature reporting.

Clinical outcomes obtained through the NTS continue to match those of international practice in the patients who are fortunate enough to access the service. 48% of the patients treated by thrombectomy recovered to full independence (modified Rankin Score 0-2) following their LVO stroke. The mortality rate was 20%. This real world experience matches that achieved in multinational randomised controlled trials (HERMES). However, stroke centres around the world continue to strive to improve outcomes by changing systems of care and have made progress.

In 2021, 90 day mRS of ≤2 indicating achievement of functional independence was achieved in 48%.

In 2021, 90 day mRS of ≤2 was achieved in 48% (n=184) of patients who underwent thrombectomy at Beaumont Hospital and CUH. 90 day mRS outcome was available in 90% (n=382) of patient who underwent thrombectomy.

Figure 2: Modified Rankin Score at Day 90



PATIENTS TRANSFERRED TO THROMBECTOMY CENTRE BUT UNSUITABLE FOR EVT

Some patients will not be suitable for thrombectomy despite being referred. Some patients will improve with thrombolysis or spontaneously. Other patients will deteriorate rapidly with or without thrombolysis. Factors involved in patients becoming unsuitable include; the time from stroke onset, the type of artery blocked the collateral score and the distance between their PSC and the endovascular centre.

Table 12: Reasons for unsuitability for thrombectomy for those transferred to Beaumont Hospital

Unsuitability Reason	N (%)
Clinical Improvement	11 (17)
No LVO	25 (38)
Established infarct	13 (20)
Haemorrhagic transformation	1 (1)
Other	16 (24)

OVERALL DATASET

Comparing these data groups we get a better picture for larger number of stroke patients. We note that patients with shorter door to CT, DTN and DIDO times are more likely to be transferred and treated.

Table 13: Overview of Beaumont Hospital Group Figures

Beaumont Hospital Group	Year	Door to CT median	Door to needle median	Door to BH contact median	DIDO (hr:min) median
EVT	**2021 (n=327)**	**00:23 (n=277)**	**00:43 (n=115)**	**00:55 (n=239)**	**01:40 (n=241)**
	2020	00:22	00:48	01:00	01:43
	2019	00:21	00:49	00:53	01:41
	2018	00:25	00:50	01:05	01:41
Transferred but deemed unsuitable on arrival at Beaumont Hospital	**2021 (n=66)**	**00:22 (n=47)**	**00:55 (n=27)**	**01:04 (n=46)**	**02:03 (n=46)**
	2020	00:35	00:51	01:12	02:04
	2019	00:30	00:57	01:17	02:08
	2018	00:31	01:00	01:27	02:20
TOTAL	**2021 (n=393)**	**00:23 (n=277)**	**00:45 (n=142)**	**00:56 (n=285)**	**01:42 (n=287)**
	2020	00:27	00:52	01:10	N/A
	2019	00:26	00:50	01:09	N/A
	2018	00:30	00:52	01:20	N/A

National Thrombectomy Service 2021-2022 Projects

The National Thrombectomy Service is committed to improving patient outcomes through the initiation, leadership and support of projects that improve pre-hospital and in-hospital pathways, processes and the infrastructure that supports the delivery of care.

PitStop Protocol

Protocol for Improving Times for STroke patients requiring Onward transfer from Primary stroke centre to thrombectomy centre.

In 2018, a new protocol was introduced in Naas General Hospital in conjunction with the National Ambulance Service and Beaumont Hospital/National Thrombectomy Service QI. This was extended in Oct 2020 to include Mullingar Midland Regional Hospital and Tallaght University Hospital and in 2022 hopes to extend to Galway University Hospital & St Luke's General Hospital, Kilkenny.

In this protocol, the ambulance crew wait for a decision regarding thrombectomy and then make the transfer, if appropriate. Door in Door out times have been reduced to 75mins, saving 25mins compared to the national average. This requires a fundamental change in how we work with the ambulance service and is very challenging to replicate.

Door to Decision in 30!

To Sustain & Spread the improvements made to date, and to identify and support the teams in the implementation of new improvements

In 2018, a QI project for the care of patients with acute ischaemic stroke commenced. The aim was to reduce the time between arrival and a decision being made regarding the suitability for EVT to 30min.

The changes implemented across the 22 hospitals involved in the project, resulted in great improvements to the patients journey.

In 2021, the sustainability of the improvements previously made was severely challenged by Covid 19 & the HSE Cyber attack .However, allowing for inter-hospital variability, the processes held up and the time metrics were sustained.

There are some steps to take in order to sustain improvements, to ensure the system and performance does not revert to old patterns.

Celebrate the success to date

Remove the old systems

Continue to measure - DATA

Embed the approach/ anchor the change

Build contingencies for outliers

Plan to continually improve

LVO Bypass Proposal

Patients identified by EMS as potentially having an LVO, in the Dublin and Cork region, to transfer directly to Beaumont or CUH EVT centers

The Large Vessel Occlusion (LVO) Bypass proposal was recommended to the National Stroke programme by NOCA through INAS based on the 2019 Annual Report. For patients not identified as LVO positive, they would be transferred to their PSC as before, and would be treated with PitStop protocol.

In 2021 INAS/NOCA reported that in the Dublin region the median time from symptom onset to recanilisation was 3hrs 11 mins for those patients admitted directly to an EVT centre (Beaumont Hospital) compared to 5hrs 8mins for those transferred to the EVT centre.

EMS crew identify severe arm and leg weakness using ACTFAST Scale

If patient is positive (i.e. likely candidate for thrombectomy) Ambulance crew call EVT centre to confirm suitability for bypass

If patient is suitable, they are brought directly to EVT centre, bypassing PSC.

Following the procedure, patients are repatriated to the PSC as soon as clinically possible following a period of observation (<24hrs)

Thrombectomy Database

The project has established an easy to use database which may be integrated with National Reporting Systems.

Together with Beaumont IT, the NTS has developed a standalone database with associated data entry system, interactive dashboard, automated reporting and accessible dataset.

This database went live in 2020 and continues to successfully provide data for the Annual Report.

For more information please contact The National Thrombectomy Service

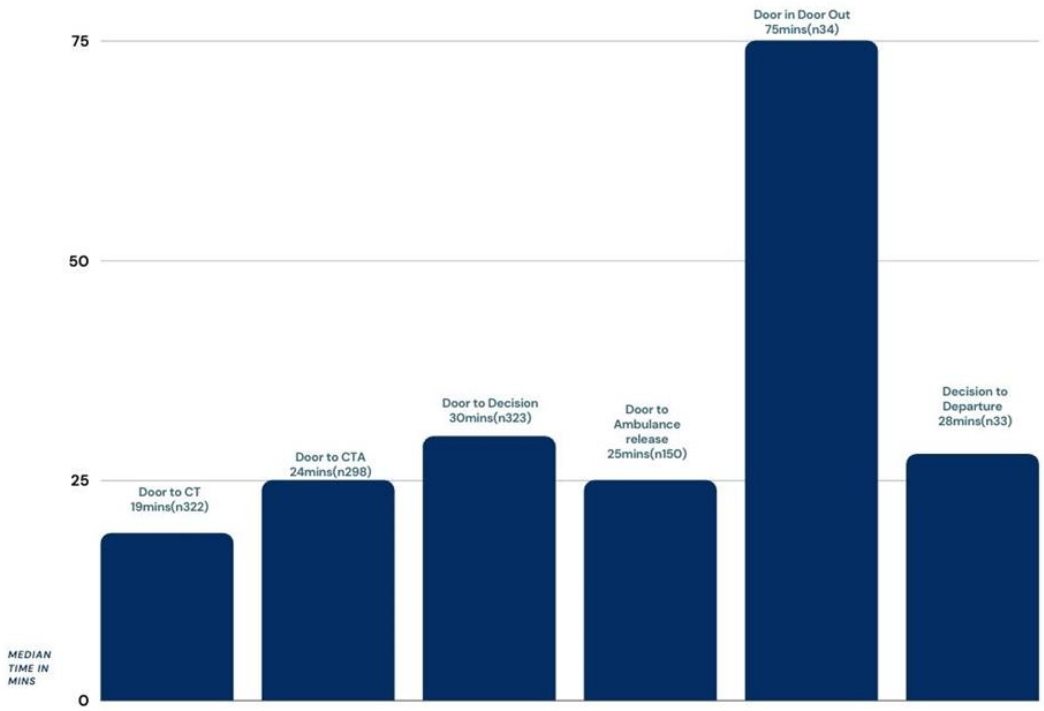
PITSTOP PROTOCOL: PROTOCOL FOR IMPROVING TIMES FOR STROKE PATIENTS REQUIRING ONWARD TRANSFER FROM PRIMARY STROKE CENTRE TO THROMBECTOMY CENTRE

In 2018/2019, a new protocol was introduced in Naas General Hospital in conjunction with the NAS and Beaumont Hospital/National Thrombectomy Service Quality Improvement. This resulted in a reduction of the DIDO times for patients from 96mins to 45mins. This protocol, now known as PITSTOP, was extended in Oct 2020 to include MRHM and TUH.

In this protocol, the ambulance crew waits with the patient on arrival to the PSC until a decision is made whether or not to transfer the patient to the endovascular stroke centre. In order for this to operate, the door to decision time must be reduced to under 30 minutes.

To measure the success of the PITSTOP protocol, data is required. As the hospitals involved are already in the QI project 'Door to Decision in 30!' the data has been collected and analysed continuously. For the PITSTOP protocol, additional data has been included to measure the efficacy of this initiative; notably 'Time of ambulance crew release', and 'Time from Decision to Departure'. The 2021 PITSTOP protocol data, for this report, shows the data collected in MRHM and TUH only.

Figure 3: Median time in mins of all PITSTOP data times stamps for 2021 (n347)



Door in door out times of PITSTOP patients (DIDO):

In 2021 there were 347 patient data sets captured using the PITSTOP protocol , 34 patients who had an LVO amenable for mechanical thrombectomy were transferred for EVT to Beaumont Hospital. This equates to 10% (n34) of all the 2021 PITSTOP patients.

Of these 34 patients transferred to Beaumont, their DIDO median times =75mins (n34),

- MRMH median DIDO = 75mins (n23)
- TUH median DIDO = 76mins (n11)

Most stroke patients brought into TUH arrive via the Dublin Fire Department (DFB) rather than the National Ambulance Service (NAS). As DFB do not make interhospital transfers, currently they are not included in the PITSTOP protocol.

In 2021 there were 32 patients transferred from TUH to Beaumont for EVT. Of the data captured, we have data sets for 11 of these patients using the PITSTOP procotol i.e. transferred via the NAS, and 19 patients transferred via the DFB (non PITSTOP). Two patients have incomplete data sets.

The median times of DIDO for the 11 patients transferred using the PITSTOP protocol (NAS) was 75mins (n11) compared to the recorded DIDO times of 19 patients using the DFB which was 81mins (n19).

- TUH median DIDO for PITSTOP patients = 75mins (n11)
- TUH median DIDO non PITSTOP patients = 81mins (n19)

The PITSTOP protocol DIDO times, compares favorably with the DIDO times for the full group of Beaumont EVT patients which is 100mins (n327). Note that the three hospitals using the PITSTOP protocol are in the top four rankings for DIDO.

Door to CT/CTA & decision times:

Our preliminary data not only shows a significant reduction in the DIDO for patients transferred for thrombectomy, but also the additional various non-thrombectomy benefits for those patients identified as not suitable for referral for EVT.

Not all patients referred for EVT are deemed suitable on arrival to the EVT centre. Of the 34pts transferred to Beaumont using the PITSTOP protocol, 7 were unsuitable for EVT on arrival.

Combining the number of Beaumont EVT patients plus unsuitable patients, we have a data set of 393 patients, 358 without the PITSTOP patients. Comparing this data with the PITSTOP patients (n34) the PITSTOP patients have a quicker median door to CT/CTA and decision times.

PITSTOP patients transferred: (Median times)

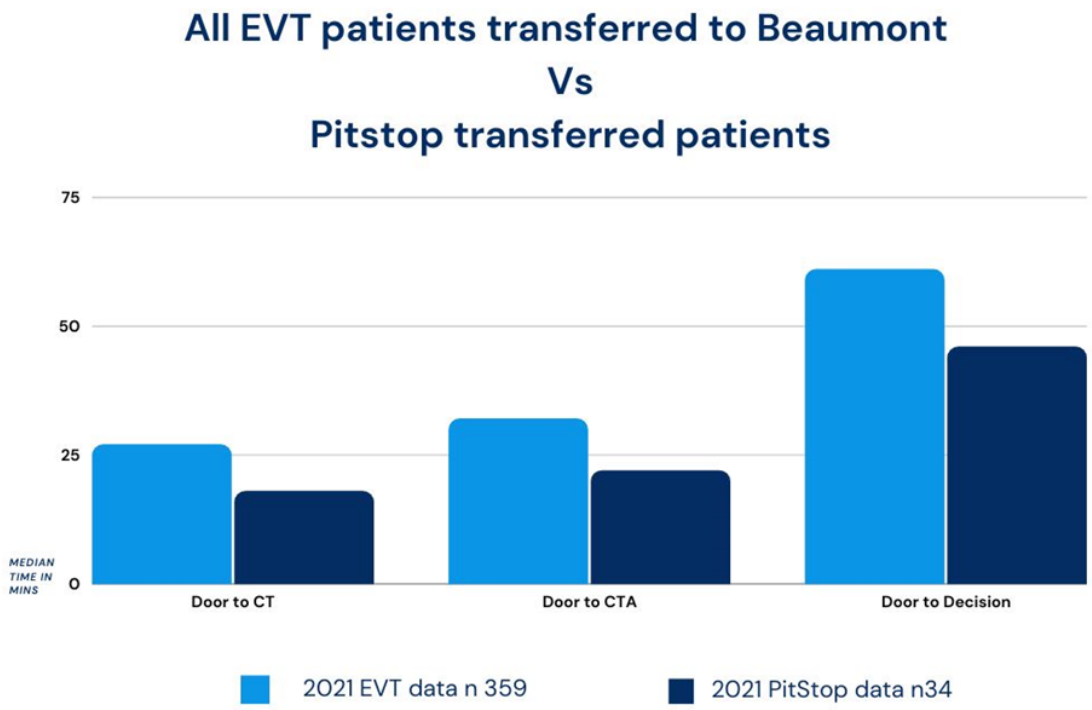
- Door to CT 18mins (n34)

- Door to CTA 22mins (n33)
- Door to Decision 46mins (n33)
- DIDO 75mins (n34)

All other pts transferred to Beaumont for EVT (including unsuitable): (Median times)

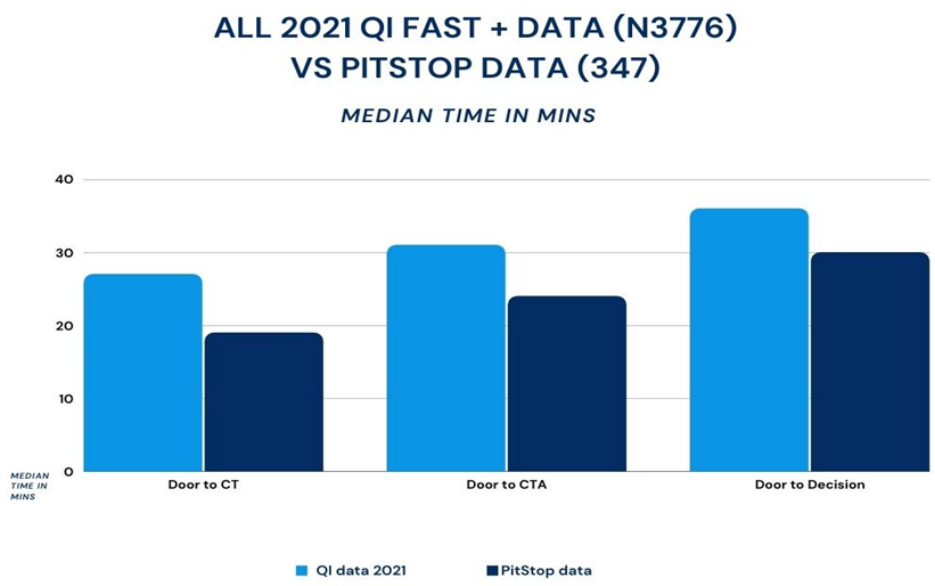
- Door to CT 24mins (n243)
- Door to CTA 29mins (n241)
- Door to Decision 61mins (n172)
- DIDO 105mins (n208)

Figure 4: Median time in mins of all EVT patients transferred to Beaumont Versus PITSTOP transferred patients for 2021



The PITSTOP data also shows faster Door to CT/CTA and decision times compared to all FAST data (see table below).This shows that the patients under the PITSTOP protocol are processed quicker than non PITSTOP patients.

Figure 5: 2021 ALL FAST positive patients (n3776) versus PITSTOP patients (n347)



Ambulance release times:

One of the key metrics of the PITSTOP protocol is the door to ambulance release time and this must be reduced to under 30mins, in order to not delay the ambulance crew. Challenges still remain and the PITSTOP hospitals have yet to achieve the Naas times of DIDO.

In 2021 the median door to ambulance release time was 25mins (n150). The impact on the door to ambulance release time is significant for both MRHM and TUH (MRHM =25mins (n67) ; TUH = 26mins (n83). This means that for non EVT patients the decision is made, and the ambulance teams are released in under 26 mins for both hospitals. This is better than the ambulance release times achieved in the Naas project as additional emphasis was placed on this aspect. Of note even though there are 347 pts under the PITSTOP protocol not all ambulance release times or decision times are captured for these patients.

MRHM door to ambulance release time = 25 mins (n67)

TUH door to ambulance release time = 26mins (n83)

10% (n34) of all PITSTOP protocol patients were referred to Beaumont from MRHM and TUH for EVT in 2021

The PITSTOP protocol developed is widely applicable and can easily be adopted by other hospital sites where a rapid door-to-decision can be achieved by an already highly functioning acute stroke team.

NATIONAL THROMBECTOMY SERVICE

PitStop

Protocol for Improving Times for STroke patients requiring Onward transfer from Primary stroke centre to thrombectomy centre.

In 2018 a pilot project was carried out between Naas General Hospital , the National Ambulance Service (NAS) and Beaumont Hospital. The ambulance crew wait with the patient on arrival to the receiving hospital (PSC) until a decision is made regarding need for EVT.
This pilot protocol , now known as PitSTop was extended in Oct 2020 to a further 2 hospitals, Mullingar Midland Regional Hospital (MMRH) & Tallaght University Hospital (TUH). Improvements have been made on the DIDO times for patients referred for an EVT. In 2021 the door to ambulance release times have been achieved in under 25mins by the PitStop protocol.

PitStop Protocol

The patient will be transferred for EVT by the same ambulance crew that transported the patient to the receiving hospital.

Ambulance crews transporting patients to these hospitals will pre alert the receiving hospital.

Decision re suitability for EVT is completed as quick as possible

On arrival to the ED the ambulance crew are met with a member of the stroke team.

PitStop Data

For more information please contact The National Thrombectomy Service

NATIONAL THROMBECTOMY DATABASE

The new electronic database created in Beaumont went live in early 2020. This database is a standalone database, which captures all the data for FAST positive patients and patients who are referred for Thrombectomy. The data captured is used for this report and to gather data for the HIPE stroke portal.

There are huge benefits to this: we can provide the feedback form with all of the patient's time metrics and the thrombectomy procedure details, immediately after the procedure is completed, ready for sending back with the patient being repatriated post thrombectomy.

In Beaumont having the greater engagement of the full stroke team in the data collection has made a significant impact on the quality and quantity of the data collected.

The data is entered in real time, by the full stroke team, not just left for the CNS/ANP to retrieve the data retrospectively. This is aided by having the database accessible on all computers in the ED , Radiology and the stroke unit.

Such live data capture facilitates our ongoing QI programme with monthly feedback at FAST meetings with the full stroke team and allows constant evaluation of the service provided. Ongoing work is being performed to improve the reporting capabilities and to enable mobile access to the database with a view to rolling this out across the RCSI group hospitals and perhaps further afield. We believe this is an excellent model for a single prospective data collection tool for all stroke requirements.

NATIONAL THROMBECTOMY SERVICE MEETINGS

Due to the impact of Covid 19, we have been unable to host another 'in person' meeting, but we are hoping to schedule an event for autumn 2022.

LVO – LARGE VESSEL OCCLUSION PATHWAY

In 2019 INAS/NOCA reported the median time from symptom onset to arrival at EVT centre of 1hr 33mins (2020: 1hr 34min) for patients who arrived directly to the EVT stroke centre compared to 4hrs (2020: 4hs 25mins) for those who were transferred from PSC.

They also reported the median time from symptom onset to recanalisation time of 3hrs 32mins (2020: 3hrs 39mins) for those presenting directly to EVT centres and 4hrs 39mins (2020: 5hrs 12mins) for those using the drip and ship model. One of the key recommendations from the 2019 &2020 INAS/NOCA report was to develop a pilot LVO pathway.

In the Dublin region in 2021, this current report shows the median time from symptom onset (witnessed and LSW group) to recanalisation was 3hrs 11 mins for patients admitted directly to the EVT centre (Beaumont Hospital) and 5hrs 5mins for those transferred to the EVT centre.

In this proposed pathway patients in the Dublin region who are identified as potentially having an LVO stroke, would be transferred directly to Beaumont Hospital EVT centre for treatment. The initial assessment by the ambulance crew would identify severe arm and leg weakness by using the

ACTFAST scale. If positive, the ambulance crew would contact the EVT centre directly to confirm suitability for bypass. The patient is then brought directly to the EVT centre, bypassing the PSC. Following the procedure, the patient would be repatriated to their PSC as soon as is clinically possible following an observation period.

The recommendation to the NSP is for the NTS to work with the NSP, CAG and acute hospital division of HSE to develop this for Beaumont Hospital and CUH.

At the time of writing we are waiting for a steering group to be implemented.

Table 14: Onset metrics for 4 EVT groups with a witnessed onset of symptoms (n=156)

Groups	Onset to Primary Hospital *(excludes Inpatients at time of stroke)*	Onset to EVT centre	Onset to Groin puncture	Onset to reperfusion *(excludes failed EVT procedures)*
All	1hr 22mins (n=121)	3hrs 41min (n=152)	3hrs 54mins (n=155)	4hrs 16mins (n=149)
Beaumont only	45mins (n=11)	45mins (n=11)	1hr 38mins (n=14)	2hrs 25mins (n=14)
Dublin Region (Connolly, MMUH, SVUH, SJH & TUH)	1hrs 27mins (n=56)	3hrs 20mins (n=67)	3hrs 35mins (n=67)	3hrs 51mins (n=64)
Transfers ex BH and Dublin sites	1hr 27mins (n=53)	4hrs 47mins (n=70)	5hrs 12mins (n=70)	5hrs 38mins (n=67)
All except Beaumont	1hr 27mins (n=110)	3hrs 54mins (n=141)	4hrs 04mins (n=141)	4hrs 23mins (n=135)

Table 15: Onset metrics for 4 EVT groups with a witnessed & LSW onset of symptoms (n=327)

Groups	Onset to Primary Hospital *(excludes Inpatients at time of stroke)*	Onset to EVT centre	Onset to Groin puncture	Onset to reperfusion*(excludes failed EVT procedures)*
All	2hrs 31mins (n=276)	5hrs 27mins (n=319)	5hrs 48mins (n=326)	6hrs 15mins (n=317)
Beaumont only	2hrs 29mins (n=36)	2hrs 29mins (n=36)	2hrs 46mins (n=43)	3hrs 11mins (n=42)
Dublin Region (Connolly, MMUH, SVUH, SJH & TUH)	2hrs 30mins (n=111)	4hrs 23mins (n=130)	4hrs 40mins (n=130)	5hrs 5mins (n=125)
Group: Transfers ex BH and Dublin sites	2hrs 39mins (n=129)	6hrs 37mins (n=148)	7hrs 02mins (n=148)	7hrs 19mins (n=145)
Group: All except Beaumont	2hrs 34mins (n=240)	5hrs 35mins (n=283)	5hrs 55mins (n=283)	6hrs 20mins (n=275)

NATIONAL STROKE QUALITY IMPROVEMENT PROJECT

In 2018, the National Thrombectomy Service and Beaumont Hospital Stroke team, in conjunction with the Royal College of Surgeons (RCSI) of Ireland and initially with expertise from RCPI, commenced the national Quality Improvement (QI) Collaborative Project "Door to Decision in under 30!". The aim of this collaborative was to improve the interval between the time of the arrival of the patient in hospital and the decision to treat and initiate treatment by working on the clinical and radiological processes.

The primary outcome metric was the "door to decision" time i.e. the time interval between arrival at hospital and a decision being made regarding the suitability of the patient for emergency thrombectomy. This presumes a prior decision regarding thrombolysis and its commencement when indicated.

The official collaborative process, comprising formal learning sessions and action periods, ended in June 2019. However, all participating hospitals, (excluding Portiunucla, Naas, St James & SVUH) committed to continue engaging with the project and almost all managed to continue collecting data and testing service improvements into 2021.

Despite the challenges of Covid 19 and the Cyber-attack on the HSE, in 2021 the hospitals involved in the 'Door to Decision in 30!' project managed to collect substantial amounts of FAST+ patient datasets. Congratulations to all on continued improvements and sustainability.

The amount of Decision times captured has increased significantly since 2020 (up over 800) with each team focusing on capturing the moment when the decision is made to step down the FAST call, suitability re TPA and or consideration for EVT. There were 2656 decision times captured in 2021 compared to 59 decision times captured in 2018. In addition a very high percentage of FAST calls have CT and CTA times captured.

By capturing this decision time, we are identifying the acute FAST response and quick decision making regarding the ongoing care for the patient.

Despite the challenges of Covid 19 & the cyber-attack on the HSE, in 2021 the hospitals involved in the 'Door to Decision in 30!' project managed to collect substantial FAST+ patient datasets with faster times recorded in the majority of the hospitals.

The data collected by each team aims to reflect not only the patients journey from arrival to the hospital, to decision for those who progress to EVT, but also the activities of the teams responding to all the FAST calls, even if the patients do not require thrombectomy or are not having a stroke.

Many of these patients would not be captured in the INAS but do represent a considerable workload for any give stroke service. We do acknowledge that not all FAST+ calls have been captured or have completed data sets as each team vary in their ability to continue to collect the data.

Table 16: 2021 Comparison of FAST positive data

Date Range	Fast+ Patients Total	Total "Time Of Decision" Recorded (%)	Median Door To CT[1] {IQR}	Median Door To CTA[1] {IQR}	Median Door To Decision[1] {IQR}
Jan – Dec 2018[1]	383	59 (15.4%)	30mins {17-78mins} n358	35mins {24-66mins} n272	71mins {42-131mins} n54
Jan – Dec 2019[2]	3740	1562 (43.4%)	32mins {18-61mins} n3050	34mins {22-59mins} n2131	37mins {23-62mins} n1462
Jan – Dec 2020[3]	3796	1891 (50%)	29mins {18-53mins} n3345	33mins {23-53mins} n2452	43mins {27-68mins} n1830
Jan – Dec 2021[4]	3776	2656 (70%)	27mins {18-48mins} n3175	31mins {23-49mins} n2404	36mins {23-59mins} N2656

- [1] 17 hospitals
- [2] 23 hospitals (St. James not included)
- [3] 22 hospitals in total (St. James & Portiuncula not included)
- [4] 20 hospitals in total (Naas, St. James ,Portinuncula & SVUH not included)

Interquartile Ranges (IQR):

In 2021 there were 3776 FAST + data sets captured nationally. The data is presented firstly as the median value and secondly showing the interquartile ranges.

These interquartile ranges show the difference between the first and the third quartile. The 2021 data shows a reduction in the interquartile ranges for Door to CT/CTA and Decision times, which show greater improvements in the equality of care for all patients.

Figure 6: 2021 Door to CT per year showing improvements in the IQR

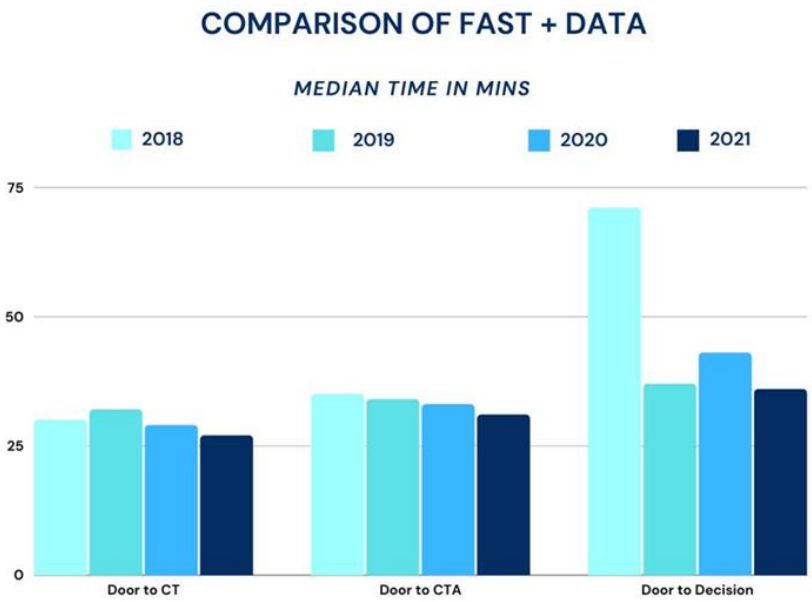


Figure 7: 2021 Door to CT per year showing improvements in the IQR

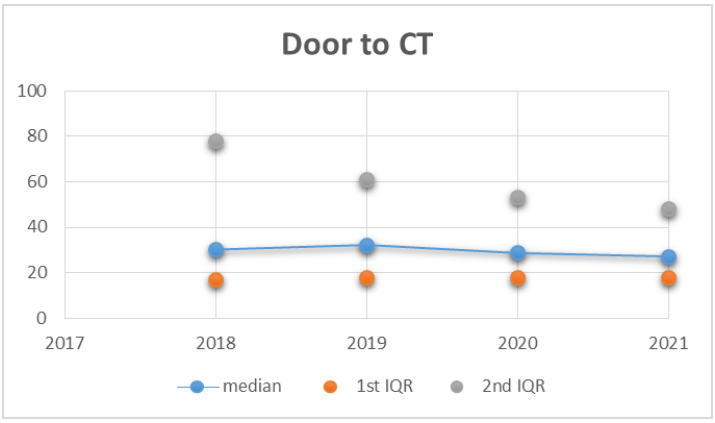


Figure 8: 2021 Door to CTA per year showing improvements in the IQR

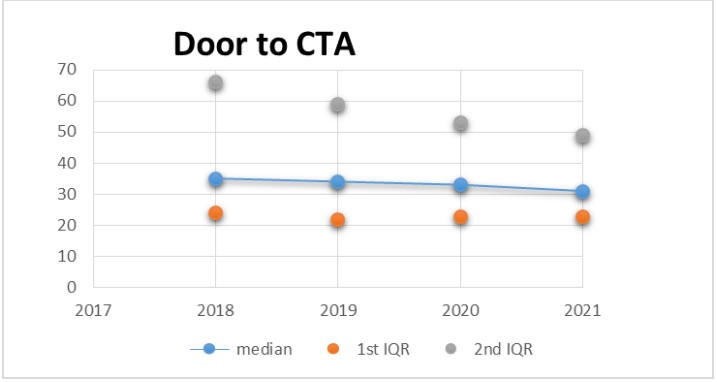
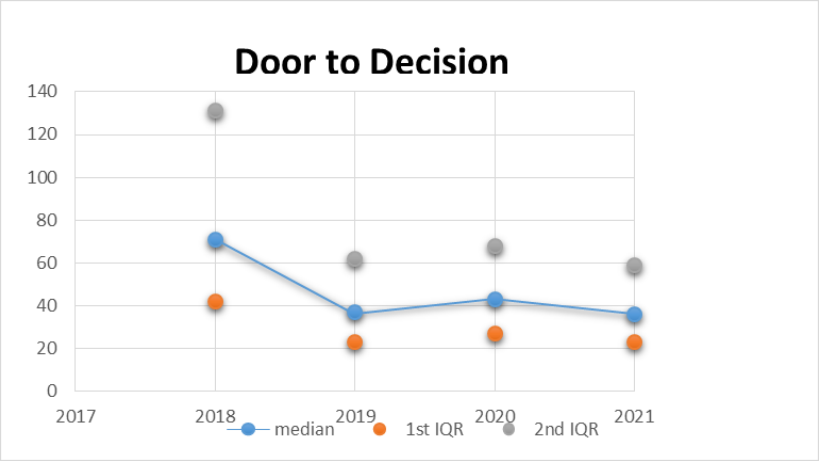


Figure 9: 2021 Door to Decision per year showing improvements in the IQR

(*Of note there have been significantly more decision times captured in 2021 (n2656) than in 2019 (n1462))*

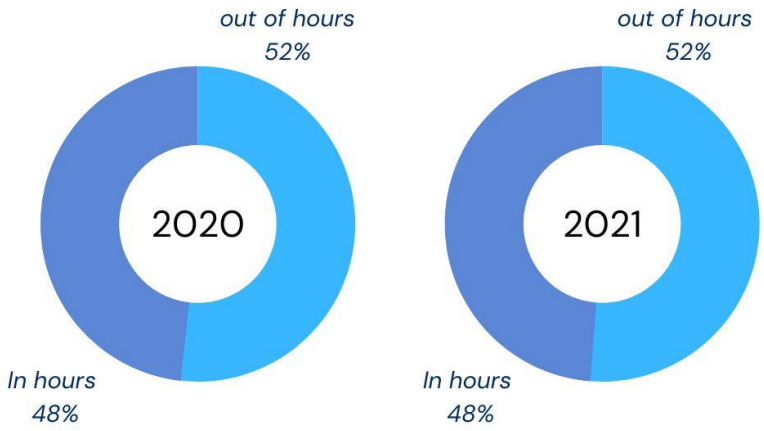


IN HOURS VERSUS OUT OF HOURS

For this report the 'in hours' is defined as Monday to Friday 8am to 5pm and the 'out of hours' is defined as all other times (including public holidays and weekends).

The initial focus of the QI project was to concentrate on the 'in hours' systems and processes, with the aim of making changes to improve these processes. The 'out of hours' processes have also improved as a result but delays still exist. The proportion of patients who presented 'in hours' and 'out of hours', remained consistent throughout 2021 (see fig 8).

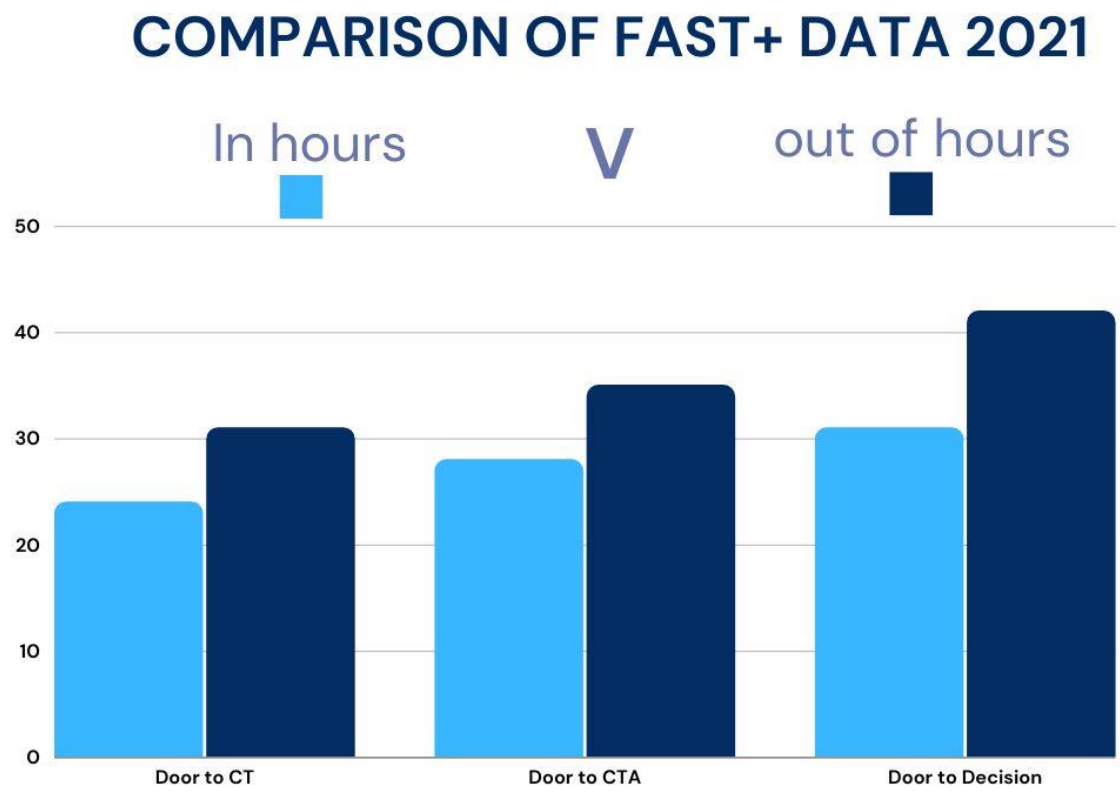
Figure 10: Comparison of number of patients presenting as FAST positive in hours versus out of hours per year.



As per (Fig 11) below ,the 'in hours' times for Door to CT, Door to CTA, Door to Decision & in 2021 have improved compared to 2020 times, but the 'out of hours' times still remain slower. Whilst trying to provide a 24/7 stroke service, challenges including lack of access to imaging and reports, not having staff onsite 24/7 and lack of access to key clinical decision makers.

Considering the number of patients presenting 'in hours' & out of hours is split 52/48 this shows the importance of establishing standardized processes which can be adapted for 24 hours per day.

Figure 11: Comparison of FAST positive Data in hours versus out of hours



ROOM FOR IMPROVEMENT

Whilst the data for 2021, showed some faster times, there is always room for improvements. Part of the QI process is to ensure that the improvements made are sustainable. For the result of the collaborative to be sustained and improved it is important that the work is owned and integrated into mainstream services and infrastructure.

The National Stroke Strategy for 2021-2026, (National Stroke Programme, 2020) recognise that the acute treatment for patients with ischaemic stroke, especially in the time sensitive treatments of thrombolysis and thrombectomy, is an area requiring continuous quality improvement.

A recommendation from the strategy is that all hospitals receiving acute stroke patients have access to specialist opinion with acute stroke treatment and specialist-led rapid access stroke service or access to such a service within their hospital network. This service must have adequate staffing and diagnostic resources to provide 24/7 acute stroke care and treatment. It is also recommended that all patients recovering from a stroke have access to a similar specialist secondary prevention stroke service and diagnostics (NSP, 2020).

Continuous quality improvement is required to ensure old patterns of working do not remerge

The need for continuous quality improvements highlights the importance for teams to lock in the progress that has been made and to continually build upon it.

The QI process has shown us how to set goals, identify change ideas and measure to see if changes are an improvement. Going forward we can continue to apply these techniques in response to patients' needs, best practices and policy changes.

Table 17: 2021 Fast Positive Patient Data by Individual Hospital

Hospital	Date Range	2021 Fast+ Patients Total N (relative to 2020 N) {2021 Total Ischaemic Strokes as per HIPE }	Total "Time Of Decision" Recorded (%)	Median Door To CT[1] Mins {IQR}	Median Door To CTA[1] Mins {IQR}	Median Door To Decision Regarding Thrombectomy[1] Mins {IQR}
[2]Bantry	Jan – Nov 2021	49(↑25) {64}	37 (76%)	14 (↓3mins) {5-30mins} N48	30(↓33mins) {20-52mins} N15	37(↑15mins) {14-66mins} N37
Beaumont	Jan – Dec 2021	613 (↑107) {307}	465 (90%)	27(↓1mins) {19-42mins} N505	31(↓1min) {24-48mins} N476	35(↓2min) {26-53mins} N465
[3]Cavan General Hospital	Jan – Dec 2021	32(↑6) {147}	10 (31%)	47(↑26mins) {29-66mins} N30	52(↑30mins) {36-72mins} N30	105mins {81-140mins} N10
Connolly Hospital	Jan – Dec 2021	118(↑10) {213}	118 (100%)	24(↓7mins) {17-39mins} n112	30(↔) {22-50mins} N81	30(↓4mins) {19-46mins} N118
Cork University Hospital	Jan – Dec 2021	480(↑31) {431}	466 (97%)	32(↓3mins) {21-96mins} N435	31(↔) {22-56mins} N227	30(↓9mins) {22-46mins} N466
[3]OLOL Hospital Drogheda	Jan – Dec 2021	44(↑4) {244}	0%	17(↓2mins) {13-53mins} N36		
University Hospital Galway	Jan – Dec 2021	274(↓131) {262}	51 (11%)	29(↓10mins) {20-70mins} N227	30(↓1mins) {23-51mins} N180	51(↓9mins) {35-86mins} N31
University Hospital Kerry	Jan – Dec 2021	238(↑6) {131}	207 (88%)	22(↑1mins) {17-35 mins} N211	28(↑1min) {21-41 mins} N188	60(↑1mins) {41-91mins} N207
St Lukes Hospital Kilkenny	Jan – Dec 2021	96(↑24) {117}	36 (35%)	37(↑2mins) {25-56mins} N59	37(↑1min) {29-50mins} N33	40(↓20mins) {21-59mins} N35
Letterkenny University Hospital	Jan – Dec 2021	85(↑18) {168}	9 (10%)	32(↓12mins) {21-47mins} N84	35(↓16mins) {23-53mins} N72	45(↓43mins) {43-100mins} N9
University Hospital Limerick	Jan – Dec 2021	72(↓95) {329}	32 (44%)	27(↓11mins) {19-40mins} N69	42(↓11mins) {29-60mins} N53	68(↑3mins) {46-101mins} N32
Mater Misericordiae	Jan – Dec 2021	346(↓167) {262}	309 (89%)	20(↓2mins) {14-30mins} N341	25(↓3mins) {20-35mins} N310	36(↓20mins) {25-52mins} N309
Mayo University Hospital	Jan – Dec 2021	117(↓3) {138}	50 (43%)	58(↑13mins) {40-80mins} N111	54(↑6mins) {43-84mins} N76	80(↑18mins) {44-115mins} N50
Mercy University Hospital	Jan – Dec 2021	7(↓13) {99}	7 (100%)	25(↓6mins) {23-50mins} N7	54(↑13mins) {47-65mins} N4	38(↓3mins) {20-72mins} N7
MRH Mullingar	Jan – Dec 2021	281(↑112) {148}	247 (88%)	22(↑2mins) {15-34mins}	27(↓2mins) {20-37mins}	35(↑5min) {23-56mins}

				N254	N251	N247
[3]Sligo General Hospital	Jan – July 2021	17(↓13) {202}	6 (35%)	33(↓9mins) {23-43mins} N15	34(↓10mins) {26-55mins} N16	70(↑25mins) {48-105mins} N6
South Tipperary General Hospital	Jan – Dec 2021	70(↑9) {102}	70 (100%)	24(↓3mins) {18-35mins} N70	34(↓4mins) {25-43mins} N28	36(↓3mins) {21-49mins} N70
Tallaght University Hospital	Jan – Dec 2021	423(↑165) {273}	413 (98%)	24(↓11mins) {16-42mins} N325	29(↓10mins) {21-46mins} N282	36(↓5mins) {20-57mins} N413
University Hospital Waterford	Jan – Dec 2021	204(↑113) {141}	49 (24%)	36(↑4min) {23-79mins} N173	46(↑1min) {32-100mins} N125	45(↓1mins) {20-80mins} N49
Wexford General Hospital	Jan – Dec 2021	131(↑19) {160}	99 (76%)	57(↑16mins) {43-66mins} N66	68(↑15mins) {52-75mins} N32	17(↓6mins) {10-30mins} N99

- [1]Excluding inpatients
- [2]Not a full year of data provided
- [3]Data provided was Thrombectomy/Thrombolysis only pts

NOTE: The number (n) is not always the full number of patients treated ,this number can include inpatients, those who may not have had a CT or CTA, or not have had a decision time recorded

All the above data shows the 'n' of the times captured, this is not always the complete and full number as some times are not captured for eg some patients may not go on to have a CTA following a CT scan.

Although the overall data demonstrates improvement in each metric, there remains variability between hospitals. It is also interesting to note the variation in volume of fast calls registered compared with the number of stroke discharges as per HIPE data. Here we also see that the hospitals participating in PITSTOP protocol have high volumes of FAST patients captured.

In 2021, 11 hospitals attained median Door to Decision times of less than 40mins. This is higher than 2020 data of 7 hospitals. Of these 11 hospitals, 5 have achieved a median Door to Decision time of 35mins or less, with 3 hospitals attaining median Door to Decision times of less than 30mins.

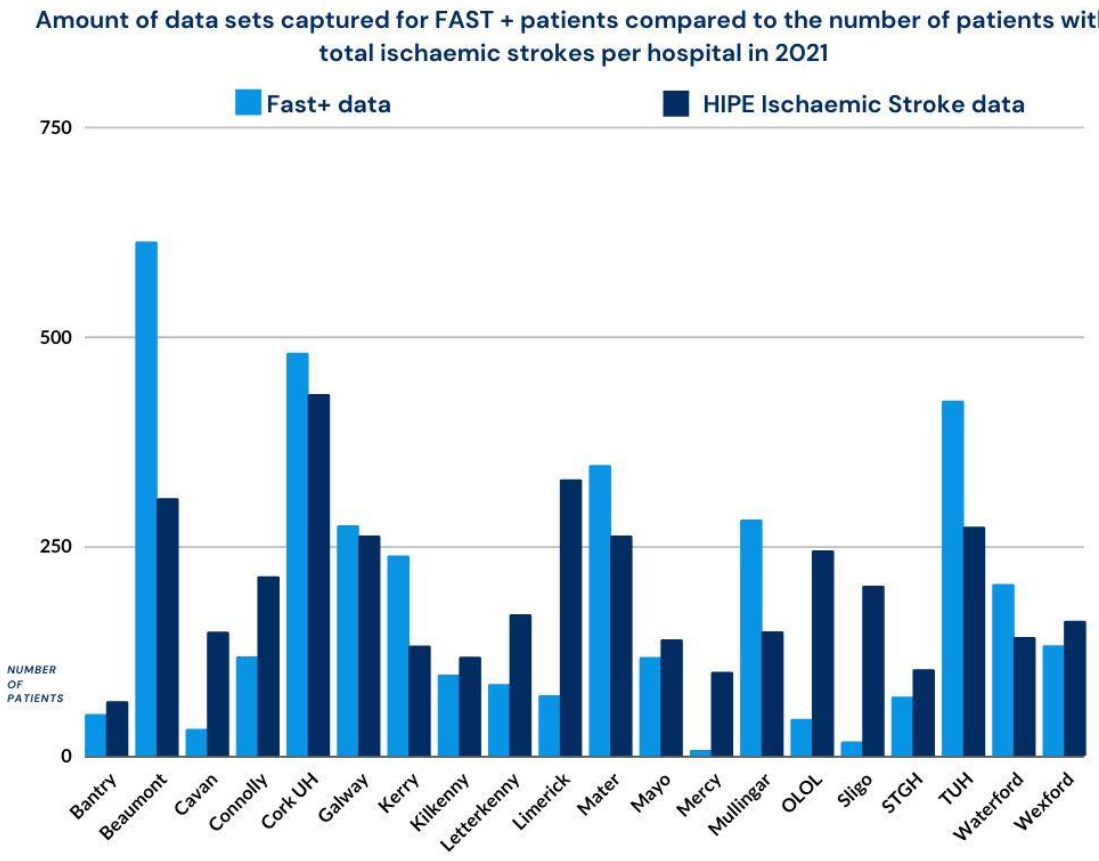
11 hospitals attained median door to decision times of less than 40mins. Of these, 5 achieved a time of 35mins or less, with 3 hospitals attaining median door to decision times of less than 30mins

The QI process involves the collaboration and cooperation of the wider MDT, however special thanks must go to the Clinical Nurse Specialists and Advanced Nurse Practitioners for their ongoing leadership of local improvement efforts and their commitment to the collection of this data.

Limitations in data collection: It is worth noting that data collection practices and definitions can vary between hospitals; therefore, the comparison of individual hospitals should be undertaken with caution. We have however engaged with teams to minimize the differences. We do acknowledge that

not all FAST+ calls have been captured or have completed data sets, as each team vary in their ability to collect the data.

Figure 12: Amount of FAST positive data sets per hospital in 2021 versus the amount of total ischaemic strokes recorded on HIPE in 2021.



Note that Tallaght and Mullingar are engaged in the PITSTOP protocol and so all FAST data is captured, significantly more than the volume of stroke discharges. This is likely a true reflection of the expected relative volume of FAST calls.

Door to Decision in 30! 2021 QI Review

A Quality Improvement Project for the care of patients with acute ischaemic stroke commenced in 2018. The aim of this collaborative is to reduce the door to decision time .
Despite the impact of COVID 19 & the HSE Cyber Attack on the stroke service, all the teams continued to work together to improve the FAST journey for our patients.

The impact of Covid 19 & the HSE Cyber Attack

In 2021 despite the ongoing impact of the Covid 19 pandemic, & the HSE Cyber attack the teams involved in the QI project, continued to sustain the changes implemented throughout the project ,to help improve patient outcomes. The teams continued to make best efforts to collect the data All time metrics collected showed improvement's, Door to CT/CTA & Decision times were all quicker than recorded times in 2020!

20

Hospitals

In 2021, the QI Collaborative incorporated 20 hospitals around the country.

3776

FAST + Patients

3776 FAST patient journeys were documented as part of the QI project in 2021.

424

Thrombectomies

In 2021, 424 patients underwent emergency thrombectomy.

Door to Decision 36 mins

43 mins → 36 mins

Median time from door to decision for treatment for all FAST+ patients was 36mins (n2656) A decrease of six minutes from 2020 (n1830)

Decisions Recorded n2656

1830 pts → 2656 pts

2656 patients had the time of decision regarding their suitability for thrombectomy recorded in 2021. An increase of 826 from 2020!

Door to CT 27 mins

29 mins → 27 mins

The median time from arrival at hospital to CT Brain was 27 mins (n 3175). A decrease of three minutes from 2020 (n3345)

Door to CTA 31 mins

33 mins → 31 mins

The median time from arrival at hospital to CT Angiography was 31 mins (n 2404). A decrease of 2 minutes from 2020 (n2452)

For more information please contact The National Thrombectomy Service

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Special mention must be made of the stroke CNS and ANPs around the country who have lead roles in rolling out the QI process in their hospitals and gathering the large volume of data which gives us a clear vision of the acute stroke pathway in their hospitals.

We acknowledge the hard work and dedication involved in data collection at time of referral, or acute admission by the radiology/stroke teams here in Beaumont - Neuroradiologists; Dr. Paul Brennan, Dr. Dr. Alan O'Hare, Dr. Sarah Power, Dr. Matt Crockett, Dr. Seamus Looby & Dr. Terence Farrell. Stroke Physicians; Prof. David Williams, Dr. Kevin Cregg, CNS; Carla O'Farrell and Emma Hickey; along with the radiology and stroke registrars, nurses and radiographers. The team in CUH - Neuroradiologists; Dr. Gerry Wyse and Dr. Noel Fanning, Stroke Physician; Dr. Liam Healy, Stroke CNS; Karena Hayes and Glen Arrigan.

Great efforts were made to ensure accuracy and analysis of the data to the best of our ability. If any further information is required, please do not hesitate to contact any of the NTS team.

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