

# Are the guidelines for treatment of myocardial infarction complied with?

**BACKGROUND** New guidelines recommend early invasive evaluation and treatment for most patients with acute myocardial infarction – including patients with myocardial infarction without ST elevation in the ECG. This study examines compliance with the new guidelines at Sørlandet Hospital Arendal.

**MATERIAL AND METHOD** All patients admitted to Sørlandet Hospital Arendal with acute myocardial infarction in 2012 were registered in the Norwegian Myocardial Infarction Register. Data from the register were used to analyse the time that passed from symptom onset to coronary angiography and revascularisation.

**RESULTS** In 2012, 788 patients were admitted to Sørlandet Hospital Arendal with acute myocardial infarction. Of these, 269 (34.1 %) had ST elevation myocardial infarction (STEMI) and 519 (65.9 %) had non-ST elevation myocardial infarction (NSTEMI). Most patients with ST elevation infarction (220 (81.8 %)) were admitted directly to Sørlandet Hospital Arendal, and the median time from admission to revascularisation was 31 minutes. 347 (66.9 %) of the patients with non-ST elevation infarction were first admitted to a local hospital before being transferred to Sørlandet Hospital Arendal. Only four (1.2 %) of them underwent angiography within two hours of admission to the first hospital. 13 (9.0 %) of the patients with non-ST elevation infarction who were admitted directly and underwent angiography ( $n = 144$ ) had an angiogram within two hours of admission. Angiography was performed within 24 hours in 119 (34.3 %) of those transferred ( $n = 347$ ) and in 82 (56.9 %) of the directly admitted patients who underwent angiography ( $n = 144$ ).

**INTERPRETATION** Many patients with non-ST elevation infarction did not receive revascularisation with percutaneous coronary intervention (PCI) within the recommended time frame. Where there is a strong clinical suspicion of acute myocardial infarction, more patients should be admitted directly to hospitals with PCI preparedness.

Each year, 12–15 000 Norwegians suffer myocardial infarction (1). In the past, the treatment strategy on suspicion of acute myocardial infarction has depended mainly on whether the ECG shows ST elevation or not. The benefit of early revascularisation by means of percutaneous coronary intervention (PCI) or thrombolysis is well documented for cases of myocardial infarction with ST segment elevation on the ECG (STEMI), where most of the patients have acute coronary occlusion (2, 3). In recent years it has been demonstrated that an ECG alone does not identify acute coronary occlusion in all patients (4, 5). Coronary angiography also reveals coronary occlusion in many myocardial infarctions without ST elevation in the ECG (NSTEMI) (6, 7). NSTEMI is more common (8) and has a poorer long-term prognosis (9) than STEMI. Revascularisation by means of PCI eliminates symptoms, shortens stays in hospital and improves the prognosis, also in the case of NSTEMI (10, 11).

The European Society of Cardiology (ESC) published new guidelines for the treatment of patients with acute coronary syndrome without ST elevation in the ECG in 2011 (12) and new guidelines for treat-

ment of myocardial infarction with ST elevation in 2012 (13). The guidelines were immediately implemented in local procedures in our hospital region. The Norwegian Cardiological Society (14) and subsequently the Cardiology Committee for the South-Eastern Norway Regional Health Authority have also recommended that they be used. Earlier invasive evaluation and treatment of NSTEMI patients in the ECG represents an important change in the new guidelines (Box 1). It is recommended that a systematic risk review be used to determine the degree of urgency for coronary angiography in NSTEMI cases (12). Patients with refractory chest pain, recurrent chest pain with ST depression or deep negative T-waves on the ECG despite anti-angina treatment, clinical symptoms of heart failure or haemodynamic instability (shock) or with life-threatening arrhythmia are defined as at very high risk and should have immediate coronary angiography, i.e. within two hours of the first medical assessment (pre-hospital or on arrival at hospital) (12).

Early coronary angiography is recommended for the other NSTEMI patients, i.e. within 24 hours of their first clinical assessment (Box 1) (12). The guidelines also apply

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## MAIN POINTS

In 2012, most patients with ST elevation myocardial infarction in southern Norway and in Telemark county underwent invasive examination and treatment within the recommended time frame

Many patients with non-ST elevation infarction did not undergo invasive evaluation by the deadlines recommended in new guidelines.

In order to bring about earlier invasive evaluation and treatment, more patients with myocardial infarction should be admitted directly to hospitals with PCI preparedness.

to patients with acute coronary syndrome *without* myocardial infarction, and invasive assessment is recommended for them if indicated by their risk profile and the findings of a non-invasive assessment. For STEMI patients, immediate coronary angiography is recommended as previously. Thrombolysis is recommended as the first choice in cases of a history of present complaint of < 2 hours, time to PCI treatment > 90 minutes and the absence of contraindications (13).

Sørlandet Hospital Arendal is responsible for invasive treatment of coronary disease for patients living in the counties of Vest-Agder, Aust-Agder and much of Telemark (a total population of about 450 000) and has 24-hour preparedness for treating acute myocardial infarction.

We used data from the Norwegian Myocardial Infarction Register to investigate compliance with guidelines for treatment of patients with myocardial infarction (12, 13) in our hospital region, placing special emphasis on compliance with the new guidelines for patients presenting with non-ST segment elevation (12). We focused on the time elapsing from the first clinical assessment to invasive evaluation and treatment. With effect from 1 January 2012, the Norwegian Myocardial Infarction Register became a national quality assurance register with a statutory duty to register all patients admitted to Norwegian hospitals with myocardial infarction (see the Cardiovascular Register Regulation, section 2-1 (16)). The Infarction Register is a part of the Cardiovascular Register, which is a country-wide register with personally identifiable information not subject to the consent of registered persons (see section 8 of the Health Register Act (17)). The Norwegian Institute of Public Health is responsible for the data in the register. All hospitals have access to their own anonymised data for use in research and quality assurance. National data will be available for the first time in 2014 due to delayed start-up at many hospitals.

### Material and method

Since 1 January 2012, all patients admitted to Sørlandet Hospital Arendal with acute myocardial infarction have been registered in the Norwegian Myocardial Infarction Register. The present study includes all myocardial infarctions registered in the period 1 January 2012–31 December 2012. The number of myocardial infarctions is checked against diagnosis searches in the hospital's patient administration system. Information about previous illnesses, risk factors, symptoms, clinical findings, assessment, treatment and clinical course as well as the times of the onset of symptoms, admission to the first hospital and treatment

are registered in accordance with the manual for the Norwegian Myocardial Infarction Register (18). All entries are made on patient discharge by a nurse specialist and are quality assured by a cardiologist before electronic reporting takes place. The diagnosis of acute myocardial infarction was made on the basis of international recommendations and was based on a rise and/or fall in troponin and one of the following criteria: ischaemic symptoms, new ST elevation/ST depression/T inversion/left bundle branch block, development of pathological Q wave, visual imaging of new myocardial damage or detection of intracoronary clot through angiography or autopsy (19). Sørlandet Hospital uses troponin T as a biochemical infarction marker and, in accordance with Norwegian practice in 2012, we used troponin T  $\geq 30$  ng/l as the limit for diagnosis of acute myocardial infarction.

The date of any initial pre-hospital medical assessment (doctor's visit, ambulance to patient etc.) is not registered in the Norwegian Myocardial Infarction Register. We therefore chose to use the time of admission to the first hospital for recording the time elapsing until diagnosis and treatment. According to the manual of the Norwegian Myocardial Infarction Register, the time when the first balloon is inflated in the coronary artery is used as the time of starting PCI in patients who have this therapy. For patients who do not have PCI, the time when the guide catheter is inserted into the artery is used as the time of starting the procedure.

The data were analysed using the statistics program SPSS (version 18.0). Continuous variables are presented as average  $\pm$  SD or median (lower, upper quartile), and differences between groups are analysed using the T test or Mann-Whitney's U test. The time from symptom onset to hospitalisation, and from hospitalisation to coronary angiography/PCI does not have normal distribution, and is therefore presented as a median with inter-quartile range. Category data are presented as numbers (%) and differences between groups were analysed using the chi-squared test. In all analyses, p-values of < 0.05 are regarded as statistically significant.

### Results

In 2012, Sørlandet Hospital Arendal treated 788 patients with acute myocardial infarction. Of these, 269 (34.1%) were classified as ST elevation myocardial infarction and 519 (65.9%) as non-ST elevation myocardial infarction. 220 (81.8%) of the patients with ST elevation myocardial infarction were admitted directly to Sørlandet Hospital Arendal. Of the patients with non-ST elevation myocardial infarction, 172 (33.1%)

### BOX 1

The European Society of Cardiology's new recommendations for coronary angiography for patients with myocardial infarction without ST elevation (12)

- Immediate angiography < 2 hours
  - Very high risk patients
    - Refractory angina
    - Recurrent angina associated with ST segment depression or deep negative T waves on the ECG despite anti-anginal treatment
    - Heart failure or haemodynamic instability
    - Life-threatening arrhythmias
  - Early angiography < 24 hours
    - High risk patients
      - Significant rise or fall in troponin
      - Dynamic ST or T wave changes

were admitted directly. Coronary angiography was performed in 144 (83.7%) of this patient group. The other 347 (66.9%) patients in this group – who all underwent coronary angiography at Sørlandet Hospital Arendal – were first admitted to one of the other hospitals in southern Norway, mainly Sørlandet Hospital Flekkefjord (n = 33), Sørlandet Hospital Kristiansand (n = 102) and Telemark Hospital (n = 202), while ten came from other hospitals. We lack information about patients with myocardial infarction who were not sent on from these hospitals for coronary evaluation, and about any patients who were sent to other hospitals offering PCI. Only 8 (1.5%) of the patients with non-ST elevation myocardial infarction who belonged to another local hospital were rerouted directly to Sørlandet Hospital Arendal because of pre-hospital clinical findings or a short travel distance.

The clinical characteristics of the patients are shown in Table 1. There were no significant differences between the group of patients who were admitted directly via an invasive centre and the group who were transferred from another hospital with respect to age, gender, ECG changes or registered risk factors. This applied to both ST elevation infarction and non-ST elevation infarction. Nor did we find any significant differences with respect to angiography results (data not shown), the percentage who underwent percutaneous coronary intervention, or hospital mortality (Table 1).

Times from onset of symptoms to revascularisation are shown in Table 2. The time from onset of symptoms to arrival at the first

**Table 1** Clinical characteristics, percentage who had percutaneous coronary intervention (PCI) and hospital mortality for patients with acute myocardial infarction with ST elevation (STEMI) and without ST elevation (NSTEMI) who underwent angiography at Sørlandet Hospital Arendal. Both patients who were admitted directly to Sørlandet Hospital Arendal and patients with myocardial infarction who were transferred from other hospitals for coronary angiography/PCI are included. Unless otherwise stated, numbers are given with percentage in brackets. There were no significant differences between patient groups who were admitted directly via an invasive centre and groups who were transferred from other hospitals

	ST elevation myocardial infarction		Non-ST elevation myocardial infarction	
	Admitted directly, N = 220	Transferred from another hospital, N = 49	Admitted directly, N = 144 <sup>1</sup>	Transferred from another hospital, N = 347
Men	171 (77.7)	37 (75.5)	97 (67.4)	247 (71.2)
Age, average number of years ± SD	64.4 ± 13.1	63.8 ± 13.7	68.6 ± 11.8	67.2 ± 12.4
Age ≥ 75 years	52 (23.6)	7 (16.7)	54 (37.5)	112 (32.3)
Previous myocardial infarction	25 (11.4)	10 (20.4)	41 (28.5)	111 (32.0)
Smoking <sup>2</sup>	99 (45.0)	21 (42.9)	44 (30.6)	103 (29.7)
Hypertension	74 (33.6)	17 (34.7)	60 (41.7)	140 (40.3)
Diabetes mellitus	20 (9.1)	5 (10.2)	24 (16.7)	74 (21.3)
New or not previously known ECG change <sup>3</sup>	220 (100)	49 (100)	80 (55.6)	203 (58.5)
Performed PCI	197 (89.5)	44 (89.8)	113 (78.5)	260 (74.9)
Hospital mortality	9 (4.1)	0 (0.0)	3 (2.1)	2 (0.6)

<sup>1</sup> 172 patients with non-ST elevation myocardial infarction were admitted directly to Sørlandet Hospital Arendal. 144 of them had a coronary angiogram, while the remaining 28 did not have an angiogram. Only patients who had an angiogram are included here

<sup>2</sup> Current or former smokers

<sup>3</sup> ST elevation, ST depression, left branch block or T wave changes

hospital was significantly lower for patients admitted directly to Sørlandet Hospital Arendal than for patients transferred from other hospitals. With ST elevation myocardial infarction, the median time from admission to coronary angiography/PCI (door-to-needle or door-to-balloon) was significantly shorter for patients admitted directly to Sørlandet Hospital Arendal (n = 220) than for patients who were admitted to another hospital first and then transferred (n = 49). Only three (6.1 %) of the patients with ST elevation myocardial infarction who were transferred were given thrombolysis before reaching or at the first hospital.

The median time from admission to coronary angiography/PCI for non-ST elevation myocardial infarction was also significantly shorter for patients who were admitted directly to Sørlandet Hospital Arendal than for patients who were admitted to another hospital first (Table 2). Coronary angiography/PCI was performed within two hours of admission for 13 (9.0 %) of directly admitted NSTEMI patients. By way of comparison, four (1.2 %) of the patients with non-ST elevation myocardial infarction who were admitted to another hospital first, underwent angiography within two hours. Coronary angiography/PCI in NSTEMI cases was performed within 24 hours on 82

(56.9 %) of the patients who were admitted directly to Sørlandet Hospital Arendal, and on 119 (34.3 %) of the NSTEMI patients who were transferred from another hospital (p < 0.001).

We found no statistically significant difference in time from admission for coronary angiography/PCI for patients who were admitted on a weekday compared with patients who were admitted on Saturday or Sunday (data not shown).

## Discussion

This study has shown that most STEMI patients living in southern Norway and in Telemark county come to invasive evaluation and treatment within the recommended time limits. For many NSTEMI patients, however, there was a long delay before revascularisation, and thus they did not receive treatment within the time limits recommended in European guidelines.

In STEMI patients, the time from symptom onset to hospitalisation was relatively short. This can probably be attributed to good pre-hospital diagnosis with direct transmission of ECGs to hospitals, an efficient ambulance service and few intermediaries to cause delays. The time from arrival at the hospital to revascularisation (door-to-needle/balloon) was also short. This survey

confirms the existence of a smoothly functioning treatment chain and high degree of compliance with treatment guidelines for the great majority of STEMI patients. Our findings are also consistent with earlier studies of the time elapsing before revascularisation in STEMI cases (20–22).

Some STEMI patients were first hospitalised without the option of percutaneous coronary intervention. This may be due to unclear symptoms, difficulty in interpretation or misinterpreted ECG or substantial comorbidity needing to be clarified first. Only three of the STEMI patients who were admitted to Sørlandet Hospital Arendal in 2012 were given pre-hospital thrombolysis. The main reason that this therapy is not widely used in our hospital region is probably the short transport time to the invasive centre. In our view, thrombolysis prior to hospitalisation or at a local hospital should nonetheless be considered for more patients with a short symptom period and long or delayed transport, also in our region.

One of the biggest changes in the new guidelines for treating patients with acute myocardial infarction is early revascularisation also in NSTEMI cases (Box 1) (12). Coronary angiography is now recommended for NSTEMI patients within two or 24 hours, depending on the risk level. The European

**Table 2** Time elapsed from onset of symptoms to coronary angiography/PCI for patients with myocardial infarction with ST elevation and without ST elevation, admitted directly to Sørlandet Hospital Arendal and patients with myocardial infarction transferred from other hospitals

	ST elevation myocardial infarction			Non-ST elevation myocardial infarction		
	Admitted directly, n = 220	Transferred from another hospital, n = 49	P- value	Admitted directly, n = 144	Transferred from another hospital, n = 347	P- value
Median symptom period <sup>1</sup> (hours (lower, upper quartile))	2.4 (1.7, 4.4)	5.1 (2.2, 16.2)	0.016	4.3 (1.7, 17.2)	11.5 (3.0, 20.9)	0.001
Median door-to-needle/balloon time <sup>2</sup> (hours (lower, upper quartile))	0.5 (0.3, 1.1)	3.3 (2.1, 15.6)	< 0.001	19.2 (4.1, 29.7)	27.7 (18.5, 52.9)	< 0.001

<sup>1</sup> Time from symptom onset to admission first hospital<sup>2</sup> Admission first hospital

Society of Cardiology's guidelines also cover patients with acute coronary syndrome without myocardial infarction (12). This group has lower risk, and they are now recommended to have coronary angiography within 72 hours, elective coronary angiography or no invasive evaluation, depending on the risk profile and the findings of non-invasive evaluation. Patients with acute coronary disease without myocardial infarction are not included in this study.

We have not identified other studies that survey delay in revascularisation of NSTEMI patients in the light of the new European guidelines. Early diagnosis – both pre-hospital and on admission to hospital – is more difficult with NSTEMI than with STEMI because there are no clear ECG criteria. The Norwegian Myocardial Infarction Register lacks detailed data on angiographic findings, but it is estimated from other studies that at least 30% of NSTEMI patients have coronary occlusion and should therefore be evaluated invasively and treated immediately (5). We believe that too few of the NSTEMI patients who are admitted directly to Sørlandet Hospital Arendal are revascularised within two hours. The detection of new regional differences in myocardial motion by means of echocardiography may help to distinguish more effectively between myocardial infarction with and without coronary occlusion (5). Echocardiography in the Emergency Department is recommended as a fixed routine in the new guidelines for acute coronary syndrome without ST elevation (12). New echocardiography modalities such as measurement of the ability of heart muscle to undergo deformation (strain) may further improve diagnostic precision (5). At Sørlandet Hospital Arendal, early echocardiography is administered to an increasing number of patients with suspected non-ST elevation myocardial infarction to improve the identification of patients for early coronary angiography/PCI. We believe nonetheless that further training

of duty doctors and a stronger focus on this patient group throughout the entire treatment chain is necessary.

Very few patients first admitted to other hospitals have had the opportunity of invasive evaluation and treatment within two hours. Improved pre-hospital work-up and risk stratification are required to treat NSTEMI patients according to current guidelines, so that they can be handled in virtually the same way as STEMI patients. Patients who according to new guidelines should have immediate coronary angiography must therefore be transported directly to an invasive centre. The majority of NSTEMI patients in our material had changes on their ECGs. Improved telemedical evaluation of pre-hospital ECGs and transmission of information from ambulance to hospital doctor could improve the identification of patients for immediate coronary angiography. This would entail some changes in the current flow of patients between hospitals, but on balance we believe it could reduce the burden on hospitals in the region, as the majority of these patients undergo an angiogram regardless during the course of their stay.

The new guidelines recommend that patients with myocardial infarction who do not undergo acute revascularisation have a coronary angiogram within 24 hours (providing there are no contraindications such as severe comorbidity or a high risk of complications). We have only partly managed to implement this change in our hospital region. The proportion of patients who undergo an angiogram within 24 hours is significantly lower for the patient group who are first admitted to another hospital before being transferred to Sørlandet Hospital Arendal than for those who are admitted directly. In order to be offered earlier invasive evaluation and treatment of non-ST elevation myocardial infarction, patients with suspected acute myocardial infarction and high risk must in

our view also be evaluated for admission directly to a hospital with PCI preparedness. Patients with chest pain who are regarded as having a low risk of myocardial infarction should, as previously, be admitted to a local hospital first for evaluation.

The study is based on relatively few patients, only one invasive centre, and embraces a limited geographical area. The composition and pattern of the population therefore have a bearing on the results. Some patient-reported information was missing from the register, and we have been unable to complete it subsequently. The time of symptom onset is based on patient reports, and is therefore somewhat uncertain. Some register parameters depend on a certain amount of individual assessment. We attempted to avoid systematic error by means of independent local quality assurance, but incorrect registration may occur nonetheless. The hospital's patient administration system was searched on diagnosis to ensure complete registration of all myocardial infarctions. Patients who due to some error had not been given a diagnosis of myocardial infarction at the time of discharge are therefore not registered in the Norwegian Myocardial Infarction Register. We have not been able to distinguish between very high risk and high risk NSTEMI patients, since this variable is not present in the register, and we are therefore unable to say how large a share of the patients should have had an angiogram within two hours. The percentage of patients with myocardial infarction who were not assessed with coronary angiography in our region is also unknown, since we did not have access to the myocardial infarction registers at the other hospitals. A similar survey of compliance with treatment guidelines should be conducted at national level when national data from the Norwegian Myocardial Infarction Register are available.

Despite the limitations described above, this study identifies a potential for improved

treatment of patients with myocardial infarction without ST elevation. In our view, this can best be solved by admitting patients directly to hospitals with PCI preparedness if there is strong clinical suspicion of acute myocardial infarction.

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