







Hospital admissions with acute coronary syndromes during the COVID-19 pandemic in German cardiac care units

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The COVID-19 pandemic is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).¹ Since February 2020, COVID-19 globally impacts public health and healthcare delivery. Resources within hospitals needed to be re-structured to cope with increasing numbers of critically ill SARS-CoV-2-infected patients, with significant consequences for all medical specialties. In addition to a rise in COVID-19-related hospital admissions, observations also noted a change in the presentation pattern of acute coronary syndromes (ACS) in highly affected regions.^{2,3} However, we do not know how these findings relate to non-overwhelmed healthcare systems.⁴ We here sought to explore the impact of the COVID-19 pandemic on ACS presentations in a fully operational healthcare system.

Germany registered its first COVID-19 case on 28 January 2020. Numbers of SARS-CoV-2-infected patients rose substantially, exceeding 100 national cases on 1 March. Consequently, counter-measures, such as social distancing, use of personal protective equipment, and a national lockdown, were implemented to prevent spreading of SARS-CoV-2. Between 1 March and 30 April 2020, >160 000 confirmed COVID-19 cases were registered in Germany. We here retrospectively analysed the numbers of patients that presented with ACS according to International Statistical Classification of Diseases (ICD) primary diagnoses [ST-elevation myocardial infarction (STEMI)/I21.0–3, non-STEMI/I21.4, unstable angina pectoris/I20.0, and cardiogenic shock/R57.0] at 15 network centres distributed across Germany providing 24/7 interventional cardiac care between 1 March and 30 April 2020. The time periods between 1 March and 30 April 2019 (the previous year) as well as between 1 January and 29 February 2020 (the same year) served as reference periods. The study protocol was approved by the local ethics committee (Technical University Munich, 197/20 S). In total, 9143 ACS

patients were analysed, of which 2509 presented during the study period. The numbers of daily admissions (incidence rates) and incidence rate ratios were computed as described previously.² The results are depicted in *Figure 1*. We found that the time period (2 months) at the peak of COVID-19 in Germany was associated with a significantly lower incidence rate of ACS presentations ($P < 0.001$). The number of patients who presented with ACS was significantly lower in comparison with the reference periods, with numbers of daily admissions of 41.1 as compared with 55.9 (previous year reference) and 53.7 (same year reference). Importantly, this reduction was observed across all ACS entities (*Figure 1*).

We wondered what were the reasons for the observed drop in ACS cases. Has the actual incidence of ACS declined or have patients been less inclined to seek medical aid because they fear that they might acquire SARS-CoV-2 infection in hospitals or because they do not want to become a burden to medical personnel dealing with COVID-19 patients? If the actual ACS incidence has not declined, one would expect that non-treated ACS, in particular myocardial infarctions, would have led to more cardiogenic shocks. However, our data indicated otherwise. We observed a relative drop in cardiogenic shock presentations too during March and April this year. Another possibility is that the actual incidence of ACS declined due to, for instance, environmental changes imposed by the lockdown (such as prevention of work-related mental stress or reduced air/noise pollution, which are known to trigger occurrence of ACS^{5,6}).

Our study should be considered in the context of the COVID-19 pandemic and the specific healthcare system it affects. Unlike most other reports on ACS presentations during COVID-19, our data derive from a medical system with at all times sufficient capacities and may be

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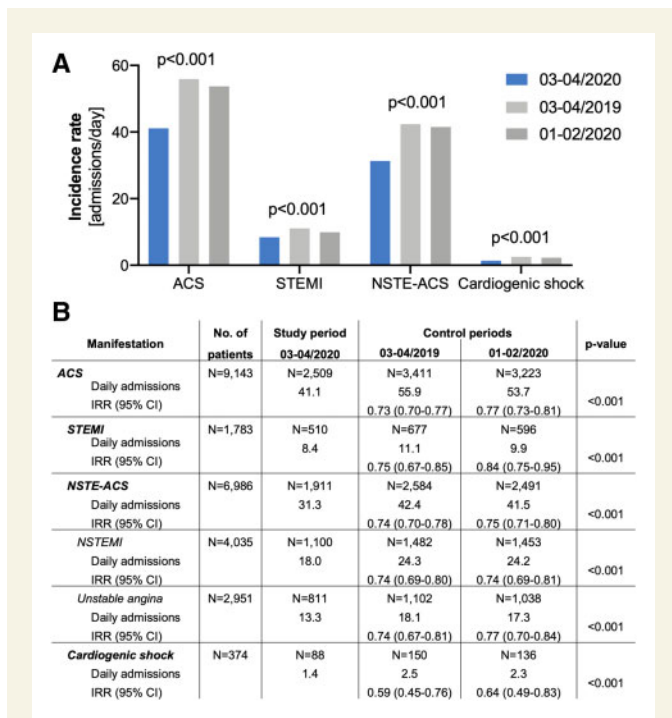


Figure 1 Incidence rates of patients presenting with acute coronary syndromes, ST-elevation myocardial infarction, non-ST-elevation acute coronary syndromes, and cardiogenic shock (A) as well as incidence rate ratios (B) during the study and reference periods at the 15 network centres in Germany. *P*-values are derived from the analyses of deviance tables for the generalized Poisson regression linear model including adjustment for network centre ACS, acute coronary syndrome; CI, confidence interval; IRR, incidence rate ratio; MI, myocardial infarction; NSTEMI-ACS, non-ST-elevation acute coronary syndrome; NSTEMI, non-ST-elevation myocardial infarction; STEMI, ST-elevation myocardial infarction.

healthcare systems need to ensure sustained medical treatment for non-COVID emergencies to avoid unfavourable long-term effects.

Data availability

The data, analytical methods, and materials that support the findings of this study are available from the corresponding author on reasonable request.

Authors' contributions

T.K., T.G., I.H., K.R., E.M., C.v.z.M., P.K., R.M.S., F.-J.N., C.B., K.L.L., S.M., H.S., J.W., A.K., and H.B.S. contributed data. T.K., T.G., J.W., A.K., and H.B.S. performed the analysis. T.K., A.K., and H.B.S. wrote the manuscript. All authors edited and approved the manuscript.

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References

- Zhou P, Yang X-L, Wang X-G, Hu B, Zhang L, Zhang W, Si H-R, Zhu Y, Li B, Huang C-L, Chen H-D, Chen J, Luo Y, Guo H, Jiang R-D, Liu M-Q, Chen Y, Shen X-R, Wang X, Zheng X-S, Zhao K, Chen Q-J, Deng F, Liu L-L, Yan B, Zhan F-X, Wang Y-Y, Xiao G-F, Shi Z-L. A pneumonia outbreak associated with a new coronavirus of probable bat origin. *Nature* 2020;**579**:270–273.
- De Filippo O, D'Ascenzo F, Angelini F, Bocchino PP, Conrotto F, Saglietto A, Secco GG, Campo G, Gallone G, Verardi R, Gaido L, Iannaccone M, Galvani M, Ugo F, Barbero U, Infantino V, Olivotti L, Mennuni M, Gili S, Infusino F, Vercellino M, Zucchetti O, Casella G, Giammaria M, Boccuzzi G, Tolomeo P, Doronzo B, Senatore G, Grosso Marra W, Rognoni A, Trabattini D, Franchin L, Borin A, Bruno F, Galluzzo A, Gambino A, Nicolino A, Truffa Giachet A, Sardella G, Fedele F, Monticone S, Montefusco A, Omedè P, Pennone M, Patti G, Mancone M, De Ferrari GM. Reduced rate of hospital admissions for ACS during Covid-19 outbreak in Northern Italy. *N Engl J Med* 2020;**383**:88–89.
- Piccolo R, Bruzzese D, Mauro C, Aloia A, Baldi C, Boccalatte M, Bottiglieri G, Briguori C, Caiazzo G, Calabrò P, Cappelli-Bigazzi M, De Simone C, Di Lorenzo E, Golino P, Monda V, Perrotta R, Quaranta G, Russolillo E, Scherillo M, Tesorio T, Tuccillo B, Valva G, Villari B, Tarantini G, Varricchio A, Esposito G. Population trends in rates of percutaneous coronary revascularization for acute coronary syndromes associated with the COVID-19 outbreak. *Circulation* 2020;**133**:916–918.
- Rosenbaum L. Facing Covid-19 in Italy—ethics, logistics, and therapeutics on the epidemic's front line. *N Engl J Med* 2020;**382**:1873–1875.
- Sager HB, Nahrendorf M. Inflammation: a trigger for acute coronary syndrome. *Q J Nucl Med Mol Imaging* 2016;**60**:185–193.
- Münzel T, Gori T, Al-Kindi S, Deanfield J, Lelieveld J, Daiber A, Rajagopalan S. Effects of gaseous and solid constituents of air pollution on endothelial function. *Eur Heart J* 2018;**39**:3543–3550.

extrapolated specifically to other countries with non-overwhelmed healthcare systems. However, a direct comparison of country-based findings is of great interest for future investigations.

Taken together, in this so far largest analysis of ACS presentations during the COVID-19 pandemic, we found a significant and consistent reduction of patients presenting with all entities of ACS as well as cardiogenic shock in a medical system with sufficient capacity. Whether the actual incidence of ACS declined or symptomatic patients did not seek medical attention needs to be further investigated. However, healthcare providers should be alerted by our data and should continue to send ACS patients to emergency departments also during pandemics such as COVID-19. Furthermore,