Seasonal trends of incidence and outcomes of cardiogenic shock: findings from a large, nationwide inpatients sample with 441,696 cases

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Research letter

An increase in the annual incidence of cardiogenic shock (CS) and a growing sub-population of patients without acute myocardial infarction (AMI) was documented in Germany [1]. However, contemporary data regarding seasonal trends of CS irrespective of the underlying cause are rare.

In this study, we aimed to analyze seasonal trends of (i) incidence; (ii) patient characteristics; and (iii) outcomes in a nation-wide sample of more than 400,000 CS cases between 2005 and 2017 in Germany.

For the present analyses, all CS cases (ICD-10-GM code R57.0) in patients ≥ 18 years between 2005 and 2017 in Germany were included. Patients were categorized based on admission in one of four groups: spring, summer, fall, and winter.

Temperature-related morbidity and mortality is a growing public health issue. Several studies outside Germany demonstrated more fatal and nonfatal cardiovascular events in the winter than in the summer [2], but contemporary data is missing. We show in our study: the highest incidence of CS was recorded during the winter, while the lowest incidence of CS was observed in the summer. The number of patients admitted with CS in the winter exceeded those in the summer by almost 10,000 (Table 1). Our study also revealed that in-hospital mortality of CS patients was higher in the winter than in the summer (winter vs. summer, n = 70,727 (61.1%) vs. n = 62,379 (58.8%), p < 0.001) (Fig. 1). Additionally, we found that patients admitted with CS in the winter were slightly older than in those admitted in the summer (winter vs. summer, mean age 71.1 (± 13.6) vs. 70.8 (± 13.8), whereas sex did not differ over the seasons (p = 0.8). Notably, incidence of AMI, pre-hospital and in-hospital cardiac arrest among CS patients varied across seasons as well (p < 0.001). This is in line with previous studies showing increased incidence of sudden cardiac death in the winter [3].

The field of temporary mechanical circulatory support (MCS) to manage patients with CS enhanced in the last decade [4]. In this study, intra-aortic balloon pump (IABP) was the most used assist device, followed by veno-arterial extracorporeal membrane oxygenation (VA-ECMO) and left ventricular assist device (LVAD) in CS patients, illustrating the perceived clinical need for MCS devices.
The multidisciplinary shock team approach utilizing protocol-driven care appears to be feasible and to reduce mortality in patients with refractory CS [5, 6]. However, the extent to which the shock team approach and associated outcomes are affected by seasonal variations remains unclear. Further studies have to elucidate whether prolonged transport time due to adverse weather conditions, atherosclerotic/thrombotic incidences in terms of AMI, and time-dependent care processes are influenced by seasonal variations and/or lower temperatures.

The strengths of this study are the large sample size and the well-validated database. Clinical variables such as age, sex, and clinical presentation, as well as outcomes such as in-hospital mortality, are presented in Table 1.

| Demographics | Winter (N = 115,710; 26.2%) | Spring (N = 108,949; 24.6%) | Summer (N = 105,980; 23.9%) | Fall (N = 111,057; 25.1%) | p value |
|--------------|-----------------------------|-----------------------------|-----------------------------|---------------------------|---------|
| Age, years   | 71.1 ± 13.6                 | 70.7 ± 13.7                 | 70.8 ± 13.8                 | 71.0 ± 13.7               | <0.001  |
| Sex, female  | 44,927 (38.8%)              | 42,141 (38.6%)              | 41,191 (38.8%)              | 43,124 (38.8%)            | 0.814   |
| In-hospital mortality | 70,727 (61.1%) | 64,382 (59.0%) | 62,379 (58.8%) | 67,381 (60.6%) | <0.001 |

Clinical presentation

| Acute myocardial infarction | 54,780 (47.3%) | 52,745 (48.4%) | 50,500 (47.6%) | 53,967 (48.5%) | <0.001 |
| Pre-hospital cardiac arrest | 16,540 (14.2%) | 16,272 (14.9%) | 16,145 (15.2%) | 16,956 (15.2%) | <0.001 |
| Intra-hospital cardiac arrest | 44,038 (38.0%) | 40,818 (37.4%) | 39,705 (37.4%) | 42,890 (38.6%) | <0.001 |
| Post-cardiothoracic surgery | 4060 (3.5%) | 3920 (3.6%) | 3842 (3.6%) | 3899 (3.5%) | 0.329 |
| Severe pulmonary embolism | 4629 (4.0%) | 4251 (3.9%) | 4374 (4.1%) | 4626 (4.1%) | 0.006 |
| Acute myocarditis | 452 (0.3%) | 318 (0.2%) | 332 (0.3%) | 368 (0.3%) | <0.001 |

Treatment

| Invasive ventilation | 52,354 (45.2%) | 48,356 (44.3%) | 46,957 (44.3%) | 49,505 (44.5%) | <0.001 |
| Non-invasive ventilation | 13,979 (12.0%) | 13,220 (12.1%) | 13,083 (12.3%) | 13,619 (12.2%) | 0.271 |
| Dialysis | 19,412 (16.7%) | 18,307 (16.8%) | 17,634 (16.6%) | 18,423 (16.5%) | 0.459 |
| IABP | 11,812 (10.2%) | 11,307 (10.3%) | 10,689 (10.0%) | 10,777 (9.7%) | <0.001 |
| LVAD | 507 (0.4%) | 494 (0.4%) | 496 (0.4%) | 468 (0.4%) | 0.398 |
| VA-ECMO | 2374 (2.0%) | 2453 (2.2%) | 2430 (2.2%) | 2568 (2.3%) | <0.001 |

IABP intra-aortic balloon pump, LVAD left ventricular assist device, VA-ECMO veno-arterial extracorporeal membrane oxygenation

Fig. 1 Overall seasonal trends of CS cases and in-hospital mortality from 2005 to 2017 in Germany. Seasonal variation in absolute case numbers of CS and in-hospital mortality rates (red line) over the seasons. Seasonal differences of in-hospital mortality: *p < 0.05 = Spring vs. Fall vs. Winter; Spring vs. Summer not significant. †p < 0.05 = Summer vs. Fall vs. Winter; Summer vs. Spring not significant. ‡p < 0.05 = Fall vs. Winter vs. Spring vs. Summer. §p < 0.05 = Winter vs. Fall vs. Spring vs. Summer.
as laboratory values, physiological markers and follow-up data beyond the hospital stay were unfortunately not available in this administrative dataset. The exact time course of the different diagnoses e.g. being prevalent at admission or incident during the hospital stay was not possible to assess in this administrative dataset. This potential bias/confounding has to be taken under consideration when interpreting our results. Finally, validation of our results outside of Germany is needed.

In this nation-wide cohort of more than 400,000 CS patients, incidence and in-hospital mortality of CS varied substantially by season, with lowest incidence/mortality during the summer and highest incidence/mortality during the winter. A better understanding of these seasonal trends, and especially if these can be attributed to temperature changes or factors related to quality of care, needs to be evaluated in future research. This might have important implications for the care of CS patients and could help to improve outcomes.

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Authors’ contributions
PMB, AG take responsibility for the integrity of the data and the accuracy of the data analysis. All persons have provided the corresponding author with permission to be named in the manuscript. Study concept and design: PMB, AG, BS. Acquisition, analysis, or interpretation of data: PMB, AG, DW. Drafting of the manuscript: PMB, AG. Critical revision of the manuscript for important intellectual content: PMB, AG, BS, NF, MS, DW, AMB, HR, PK, SB. Statistical analysis: AG, PMB, Administrative, technical, or material support: PMB, AG, BS, NF, MS, DW. All authors read and approved their final manuscript.

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Data and material are available.

Code availability
Software codes are available.

Declarations

Ethics approval
Not applicable.

Consent to participate
Informed consent was obtained from legal guardians.

Consent to publication
Not applicable.

Competing interests
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