Impact of the COVID-19 Pandemic on Interventional Radiology in Germany

Auswirkung der COVID-19-Pandemie auf die Interventionelle Radiologie in Deutschland

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ABSTRACT

Purpose To investigate the effect of the ongoing COVID-19 pandemic on interventional radiology (IR) in Germany in 2020 and 2021.

Materials und Methods This retrospective study is based on the nationwide interventional radiology procedures documented in the quality register of the German Society for Interventional Radiology and Minimally Invasive Therapy (DeGIR-QS-Register). The nationwide volume of interventions in the pandemic years 2020 and 2021 was compared with the pre-pandemic period (Poisson-test, Mann-Whitney test). The aggregated data were additionally evaluated by intervention type with differentiated consideration of the temporal epidemiological infection occurrence.

Results During the two pandemic years 2020 and 2021, the number of interventional procedures increased by appr. 4 % compared to the same period of the previous year (n = 190 454 and 189 447 vs. n = 183 123, respectively, $p < 0.001$). Only the first pandemic wave in spring 2020 (weeks 12–16) showed a significant temporary drop in the number of interventional procedures by 26 % (n = 4799, $p < 0.05$). This primarily involved interventions that were not immediately medically urgent, such as pain treatments or elective arterial revascularization. In contrast, interventions in the field of interventional oncology, such as port catheter implantations and local tumor ablations, remained unaffected. The decline of the first wave of infection was accompanied by a rapid recovery and a significant, partly compensatory, 14 % increase in procedure numbers in the second half of 2020 compared to the same period of the previous year (n = 77 151 vs. 67 852, $p < 0.001$). Subsequent pandemic waves had no effect on intervention numbers.

Conclusion The COVID-19 pandemic in Germany led to a significant short-term decrease in interventional radiology procedures in the initial phase. A compensatory increase in the number of procedures was observed in the subsequent period. This reflects the adaptability and robustness of IR and the high demand for minimally invasive radiological procedures in medical care.

Key points:

- The study shows the nationwide pandemic-related effects on interventional radiology in Germany.
- In quantitative terms, the ongoing pandemic caused a significant, temporary decline in intervention cases only in the initial phase.
- Subsequent waves of infections had no effect on the scope of services provided by interventional radiology.
- Short-term deficits, especially in elective interventions, could be partially compensated.

Citation Format

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ZUSAMMENFASSUNG

Ziel Untersuchung der Auswirkungen der COVID-19-Pandemie auf die Interventionelle Radiologie (IR) in Deutschland in den Jahren 2020 und 2021.

Material und Methoden Es erfolgte eine retrospektive Auswertung der im Qualitätsregister der Deutschen Gesellschaft für Interventionelle Radiologie und minimalinvasive Therapie (DeGIR-QS-Register) deutschlandweit dokumentierten, interventionell-radiologischen Prozeduren. Das bundesweite Interventionsvolumen der Pandemiejahre 2020 und 2021 wurde mit dem präpandemischen Vorzeitzeitraum verglichen (Poisson-Test, Mann-Whitney-Test). Die Auswertung der aggregierten Daten erfolgte zusätzlich nach Interventionsart unter differenzierter Betrachtung des zeitlichen epidemiologischen Infektionsgeschehens.

Ergebnisse In den Pandemiejahren 2020 und 2021 wurden im Vergleich zum Vorjahreszeitraum insgesamt knapp 4 % mehr interventionell-radiologische Prozeduren durchgeführt (n = 190 454 bzw. 189 447 vs. n = 183 123, p < 0,001). Lediglich in der 1. Pandemiewelle (Woche 12–16, 2020) zeigte sich ein signifikanter Rückgang der Interventionszahlen um 26 % (n = 4.799 gegenüber 2019, p < 0,05). Dabei waren vornehmlich medizinisch nicht dringliche Eingriffe, wie interventionell-radiologische Schmerzbehandlungen oder elektive arterielle Revaskularisationen, betroffen. Im Gegensatz hierzu blieben Eingriffe aus dem Spektrum der interventionellen Onkologie, wie die Implantation von Portkathetern oder lokale Tumorablationen, unbeeinflusst. Das Abflauen der 1. Infektionswelle ging mit einer raschen Erholung der Interventionszahlen und einer in der 2. Jahreshälfte 2020 signifikanten, teils kompensatorischen Leistungssteigerung um 14 % im Vergleich zum Vorjahreszeitraum einher (n = 77 151 vs. 67 852, p < 0.001). Die nachfolgenden Pandemiewellen hatten keinen Effekt auf das Interventionsvolumen.

Schlussfolgerung Die COVID-19-Pandemie in Deutschland führte nur in der Anfangsphase zu einem kurzfristigen, signifikanten Rückgang interventionell-radiologischer Prozeduren mit kompensatorischer Leistungssteigerung in der Folgezeit. Diese Dynamik zeigt die Anpassungsfähigkeit sowie auch die Robustheit der interventionellen Prozeduren der IR und macht den hohen Bedarf an minimal-invasiven, radiologischen Eingriffen in der medizinischen Versorgung deutlich.

Introduction

The severe acute respiratory syndrome known as coronavirus 2 (SARS-CoV-2) caused significant social challenges as well as major challenges for health policy structures around the world. Since the start of the first wave of infection in Germany in March 2020, both public life as well as the clinical routine at medical facilities have been subject to legal regulations with varying degrees of strictness in order to control the spread of the virus and to prevent the health care system from being overwhelmed [1]. Even after 2 years of the pandemic, the clinical routine is still affected by the dynamic infection situation.

As a cross-sectional imaging discipline with diagnostic and interventional procedures, radiology plays a central role in the care of almost all diseases. Due to technical and medical advancements, interventional radiology (IR) has become an integral part of modern medicine. In particular, vascular medicine and interventional oncology should be mentioned here. Because it is minimally invasive and highly efficient, IR has become an essential part of clinical patient care. The COVID-19 (coronavirus disease 2019) pandemic required a restructuring process in all disciplines as well as facilities performing interventional radiology to meet the treatment needs of COVID-19 patients while continuing to meet the needs of COVID-negative patients [2–5]. Even though initial analyses showed that necessary acute interventions were still able to be performed [6], the further development of the broad spectrum of necessary and elective minimally invasive interventions in the time following the pandemic in Germany has not been studied in contrast to radiological imaging [7, 8]. Therefore, the goal of this study was to evaluate the effect of the COVID-19 pandemic on IR.

Materials and Methods

Data acquisition

Our retrospective study was conducted in collaboration with the Software and the Science and Research steering groups of the German Society for Interventional Radiology and Minimally Invasive Therapy. The analysis is based on the intervention numbers documented in the quality registry of the German Society for Interventional Radiology and Minimally Invasive Therapy. Since digitalization of the registry in 1994 and the start of central server-based data collection in 2005, the registry has been recording interventional radiology procedures performed in Germany and the result quality from > 300 participating facilities. The aggregated data of all radiological interventions documented in Germany from the years 2019 to 2021 was examined. The documented date on which the service was rendered not the entry date was relevant. To prevent distortion of the data due to sporadic entries, only clinics that were consistently active from 2019 to 2021 were included (n = 263) Types of intervention that were performed less than 5 times in 2019 were excluded. Weekly intervals according to ISO 8601 (week, W) were selected for the time format. The number of interventions during the pandemic was compared to the same pre-pandemic control period and examined over the longitudinal course with a special focus on time periods with varying rates of infection (see below). In addition, the intervention volume was correlated with the hospitalization rates for COVID-19 cases published by the Robert Koch Institute as a surrogate for the pandemic pressure on the health care industry [9]. The data were smoothed for graphic representation.

▶ **Table 1** Registered Germany-wide service volume of interventional radiology procedures during the COVID-19 pandemic.

		IP	1 W	RP	SP	2 W	3 W	4 W
Total	Control period	41 795	18 543	24 314	67 852	65 657	37 275	44 168
	Pandemic	43 354 (104 %)	13 744 (74 %)	23 583 (97 %)	77 151 (114 %)	65 900 (100 %)	40 390 (108 %)	46 207 (105 %)
Interventions/ week	Control period	3800	3709	3473	3393	3648	3389	3398
	Pandemic	3941	2749	3369	3858	3468	3672	3554
p		0.65	**	0.66	*	0.49	0.08	0.45

The absolute number of cases and percentage of control period are given. *$p < 0.001$, **$p < 0.01$
IP, initial phase; 1 W, 1. pandemic wave; RP, recovery phase; SP, stabilization phase; 2 W, 2. pandemic wave; 3 W, 3. pandemic wave; 4 W, 4. pandemic wave.

Pandemic-specific phases

Based on the national rate of new infections and the resulting protective measures on the federal level, the following pandemic-specific periods were defined:

- Initial phase: CW 1–11, 2020, first sporadic infections, obligation to report, and cancellation of major events.
- First pandemic wave (1 W): W 12–16, 2020, national "hard lockdown" with comprehensive contact restrictions, extensive suspension of public life, and extensive national regulations for medical facilities to reserve treatment and intensive care capacity for potential COVID-19 patients.
- Easing of restrictions: CW 17–23, 2020, successive easing of contact restrictions and opening of businesses, initial resuming of elective procedures
- Stabilization phase: CW 24–43, 2020, extensive lifting of the restrictions listed above
- Second pandemic wave (2 W): W 44, 2020 – W 9, 2021: intensification of regulations and renewed hard lockdown in Germany comparable to the start of the first wave of infection, start of administration of vaccinations
- Third pandemic wave (3 W): W 16–26, 2021: Nationwide emergency shutdown measures, varied restrictions of public life throughout Germany depending on the 7-day rate of community spread of SARS-CoV-2, short-term regional intensive care capacity utilization with state-approved resuming of regular hospital operation at the end of May
- Fourth pandemic wave (4 W): W 40-end of 2021: Revision of the German Protection against Infection Act with public restrictions based on the community hospitalization rate.

Statistical analysis

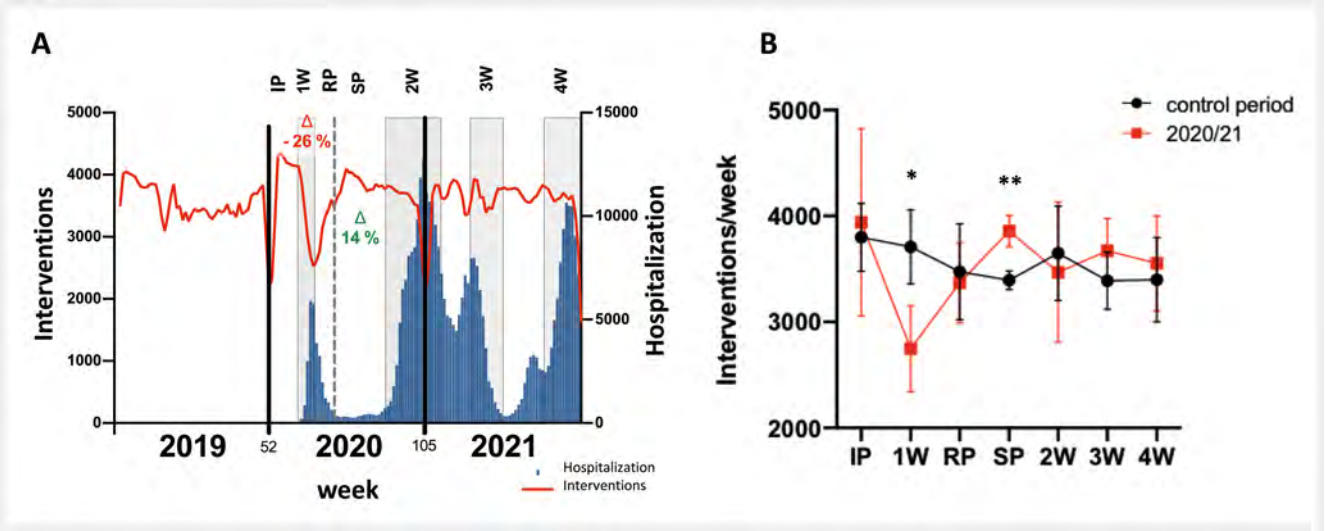
Statistical analysis was performed using GraphPad Prism 9 (GraphPad Software Inc., San Diego, USA) and R (R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/). The multicenter data was aggregated using the individual ISO weekly intervals. After exclusion of Gaussian normal distribution, phase-specific differences between the pandemic years and the corresponding control period were checked for statistical significance via Mann-Whitney test. Statistical differences in the absolute numbers for the years 2019–2021 were determined via Poisson test. The correlation between the intervention volume and the hospitalization rate was determined via Spearman test. A probability of error of $p < 0.05$ was considered statistically significant.

Results

Total examination volume

The total number of interventions in the pandemic year 2020 was 190 454 and was 4 % higher than the intervention volume for the previous year (2019: n = 183 123, $p < 0.001$). The number of interventions (189 447) remained stable to the end of 2021 and comparable to 2020. The scope of services was subject to phase-specific fluctuations. During the first wave in Germany, 13 744 interventions were performed corresponding to a reduction of 26 % compared to the previous year (2019: n = 18 543, $p < 0.05$) (▶ **Table 1** and ▶ **Fig. 1**). The nadir was reached in mid-April (W 16) with 2334 interventions/week (2019: n = 3709). At the end of the first wave, the number of examinations increased continuously and reached by the second half of the year a level comparable to that of the previous year (recovery phase: 97 % of the intervention volume in 2019, average interventions/week n = 3473 and 3369, respectively), which exceeded that of the previous year by 14 % in the stabilization phase (n = 77 151 vs. 67 852, $p < 0.001$; average interventions/week n = 3393 and 3858, respectively). In contrast to the first wave, the intervention volume during the second wave was comparable to the control period (2019/2020: n = 65 657 vs. 2020/2021 65 900). Also in the two subsequent pandemic waves in 2021 the intervention volume remained stable with the number of interventions being higher than in the control period (third wave: n = 37 275 vs. 40 390, average interventions/week n = 3389 and 3672, respectively; fourth wave n = 44 168 vs. 46 207, average interventions/week n = 3398 and 3554, respectively).

Case numbers were closely associated with the rate of new infections, the consequently mandated contact restrictions, and



▶ **Fig. 1** Chronological changes in interventional radiology service volume during the COVID-19 pandemic. **A** Graph of weekly absolute numbers over the course of the years 2019–2021. Significant changes within the defined pandemic phases compared to the control period are indicated as percentage difference. **B** Graph of average number of interventions per week during the COVID-19 pandemic compared to the control period by pandemic phase. Mean with 95 % CI. *p < 0.001, **p < 0.01. IP: initial phase; 1W: first pandemic wave; RP: recovery phase; SP: stabilization phase; 2W: second pandemic wave; 3W: third pandemic wave; 4W: fourth pandemic wave.

the requirements for medical facilities. There was a moderate, negative correlation for the weekly hospitalization rate (r = –0.49, p < 0.001) for the two pandemic years 2020 and 2021.

Effect of the coronavirus pandemic on the basis of selected interventions

Depending on the type of intervention being performed and the pandemic time period, various trends in case numbers could be observed and are presented in the following on the basis of representative examples of interventions (▶ **Fig. 2**).

Pain treatment

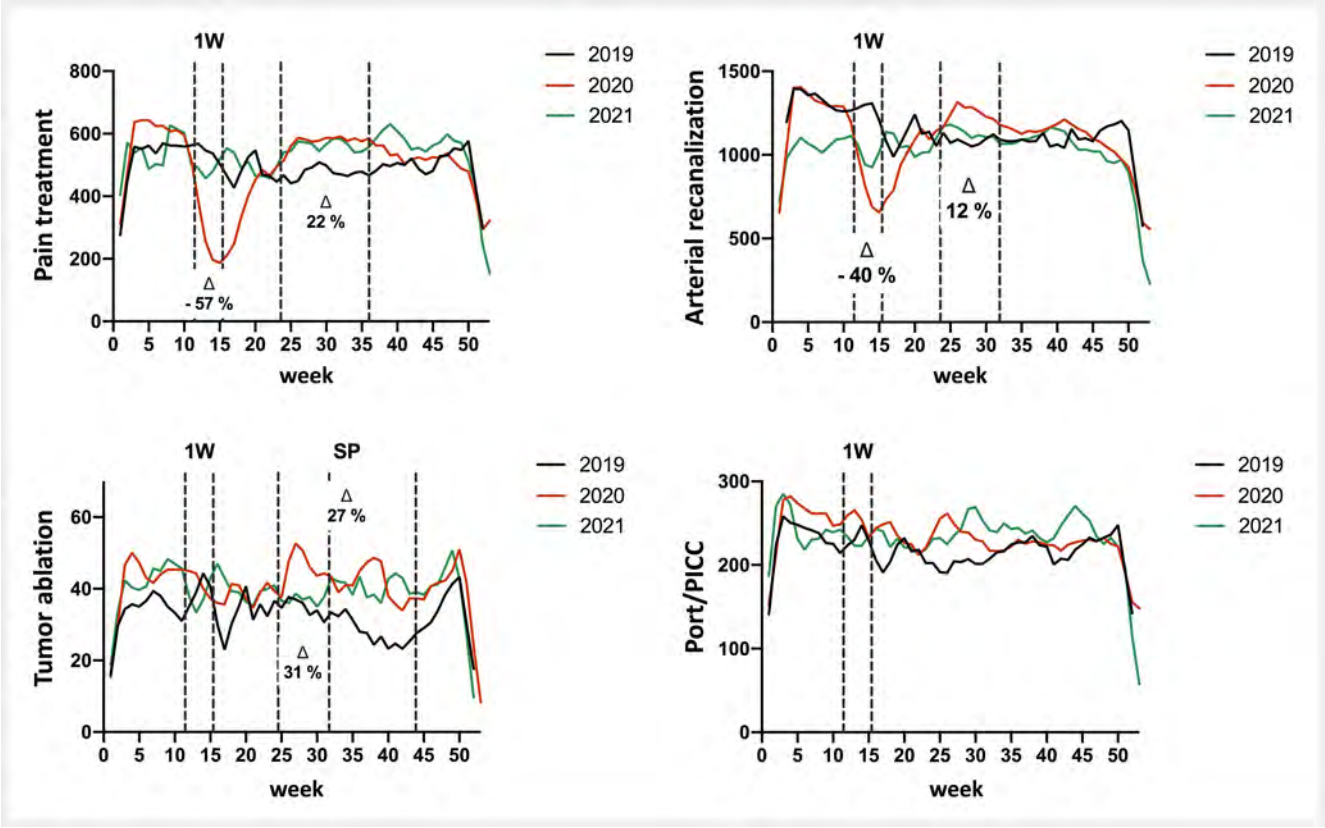
Among all interventions, pain treatment (facet joint, ganglion, and peripheral nerve blocks and periradicular nerve root therapy (PRT)) saw the greatest decrease in the number of interventions (minus 57 % (n = 1497, p < 0.01)) at the start of the pandemic compared to the previous year. The end of the first wave was associated with a continuous increase in the intervention volume with a stable increase in the intervention rate in the second half of the year compared to the previous year (W 24–36: plus 22 %, n = 1384, p < 0.001). With already declining case numbers compared to the control period, the start of the second wave did not result in a notable change in the intervention volume (n = 9561 vs. n = 9504). The number of interventions fluctuated up to and during the third wave, but otherwise remained stable at a slightly higher level (n = 5153 vs. n = 5605). The intervention rate in 2021 was 8 % higher than that of the two previous years and the number of interventions was slightly but not statistically significantly higher (n = 28 258 vs. n = 25 894 and n = 26 065).

Arterial recanalization

With respect to arterial recanalization procedures, a moderate but significant reduction was seen in 2020 and 2021 (3 % and 8 %, respectively) compared to 2019 (2019: 59 165, vs. 2020: 57 718 and 2021: 54 265; p < 0.001). During the first wave, there was a reduction in the number of interventions compared to the previous year (minus 40 % 2496 p < 0.01) and compared to the level at the start of the year (average interventions/week initial phase 1244 vs. first wave 738, p < 0.01). With the easing of restrictions, successive normalization of the intervention volume was observed with a significant increase in the second half of the year compared to the previous year (W24–32, plus 12 %, n = 1741, p < 0.001). The start of the second wave in W 44 was again associated with a decline in the number of interventions. However, it was much less extreme compared to the first wave and was not statistically significant compared to the control period (minus 10 %, n = 2054). At the start of the first quarter of 2022, the intervention volume remained stable at a lower level and remained constant even during the subsequent waves of infection compared to the control period (n = 12 031 and 13 660 vs. n = 12 041 and 13 497).

Ablation procedures

Compared to the previous year, no significant decrease in the number of ablation procedures was seen during the first wave (n = 189 vs. 202, p = 0.84). No change was seen compared to the initial level at the start of the year (average interventions/week initial phase n = 41 vs. n = 40). In the stabilization phase compared to 2019, the number of ablation procedures was significantly higher (n = 853 vs. n = 609, p < 0.001) with a rapid increase immediately after the end of all restrictions (W24–32, average interven-



▶ **Fig. 2** Temporal changes in interventional radiology service volume of sample procedures during the COVID-19 pandemic. Weekly absolute numbers of interventional pain treatments, arterial recanalizations, local tumor ablations, and port/PICC line installations over the course of the years 2019–2021 are given. Significant changes within the defined time periods compared to the control period are indicated as percent difference. 1W: first pandemic wave; SP: stabilization phase.

tions/week n = 44 vs. recovery phase n = 40). At the end of the year, the intervention volume exceeded that of the previous year by 27 % (n = 2152 vs. n = 1693, p < 0.001). Under consideration of the usual fluctuations, the subsequent waves of infection did not have a noticeable effect on the intervention volume. The number of interventions performed in 2021 (n = 2048) was comparable to the number performed in 2020 and was significantly higher compared to 2019 (p < 0.001).

Port/PICC line implantation

The number of port and PICC line (peripherally inserted central catheter) implantations remained stable during all pandemic phases. Compared to the control year 2019, the intervention volume was 8 % and 10 % higher in pandemic years 2020 and 2021, respectively (12 292 and 12 325 vs. 11 359, p < 0.05).

Discussion

Based on the national quality registry of the German Society for Interventional Radiology and Minimally Invasive Therapy, the present study discusses the fluctuations seen in the number of interventional radiology procedures performed during the ongoing COVID-19 pandemic. The consistently high intervention volume in spite of temporary decreases in the number of interventions reflects the need for minimally invasive radiological interventions and highlights the importance of IR in clinical care.

The serious effects of the COVID-19 pandemic on the health care industry, the medical services available to patients, and on radiology have been shown in global studies [10–12]. The general decline in intervention numbers at the start of the first wave is not surprising in light of the fact that both society and the health care system were unprepared to be confronted with a novel viral infection. This decrease coincides with studies of other interventional radiology facilities who reported a decline in intervention volume of 16–62 % in the first wave in 2020 [13]. Our analysis shows that the decline in infections and the easing of restrictions resulted in not only rapid normalization of intervention numbers but also elimination of the initial deficit due to a significant increase in interventions in the second half of the year compared to the previous year. The increase in interventions proves not only the ongoing need for interventional procedures but also the assumption that delayed interventions were able to be subsequently performed at least to a relevant degree. In contrast to the first wave, no major change in the scope of services was able to be detected during the following waves of infection. In spite of the significantly higher SARS-CoV-2 incidence rates and the consequently higher hospitalization rates with medical capacity being maxed out, the intervention volume remained stable. This is even more note-

worthy since increasing workforce shortages due to absences of employees in quarantine probably played a role compared to the first wave [14]. In contrast, other interventional radiology facilities around the world reported a decline in the number of services of up to minus 19 % at the end of the first year of the pandemic in 2020 [15, 16]. Compared to the first wave of infection, the improved level of preparedness of medical facilities thanks to the implementation of instructions for reorganizing departmental workflows and the availability of vaccines probably had an impact here. The change in the public perception of COVID-19 disease with a decrease in the fear of infection and increased demand for medical services are also a main factor here [17]. However, it should be noted here that particularly in the third and fourth waves of infection there were no consistent national regulations but rather restrictions depending on regional infection rates on a community level so that the effect of these waves may have been underestimated in our Germany-wide analysis. Lastly, it should be mentioned that the decline in the number of interventions during the first wave was less dramatic than the typical seasonal reduction in services at the end of the year due to the holidays. This may help to put at least the fear of not being able to provide adequate medical care into perspective.

Differentiated analysis of various interventional procedures shows that the dynamic development of the COVID-19 pandemic with its waves of infection and correspondingly adjusted restrictions did not effect all interventions and thus all areas of medical care equally. The phase-specific effect of the pandemic as observed for the entire IR service spectrum in our study is most clearly shown by the development of the number of arterial recanalization procedures. The surgical and interventional care of patients with peripheral artery disease depends on the degree of severity of the disease. While patients with critical ischemia (Fontaine stages 3 and 4) require immediate surgical and/or interventional treatment, an elective intervention is reasonable in patients with intermittent claudication (Fontaine stage 2) [18]. With the start of the first wave, the number of arterial recanalization procedures decreased significantly, which can be explained by the postponement of interventions capable of being scheduled. Comparable developments were also seen in other facilities around the world. For example, Bérczi et al. reported not only a decrease in therapeutic revascularization procedures of the lower extremities during the first half of 2020 but also a relative increase in severe disease stages [19]. Fortunately, our analyses showed not only a successive and rapid recovery of the intervention volume after the first wave but also growth compared to the previous year. This at least indicates a certain catch-up effect. A comparable trend could also be observed in interventional pain treatment, like facet joint blocks and periradicular therapies, with the decrease at the start of the pandemic being significant (over 50 %). It can be assumed that patients with chronic pain attempted to live with their pain or to manage their pain independently by self-medicating due to a fear of COVID infection at private practices and hospitals. Therefore, increased demand for services with the abatement of the first wave of infection is understandable and highlights the need for image-guided pain treatment.

Denys et al. reported the high value of interventional oncology, particularly in times of limited resources [20]. It can be deduced in the present study that the care of oncology patients as a particularly vulnerable patient cohort was maintained during the entire pandemic based on the example of the consistent number of port and PICC line implantations as a basic measure. However, it must be assumed that particularly the start of the pandemic resulted in a worsening of medical care also for tumor patients. In a retrospective multicenter study from France, Amaddeo et al. examined the effect of the COVID-19 pandemic on the management of HCC patients and identified a delay not only in initial diagnosis but also in the initiation of treatment compared to the previous year [21]. Fortunately, the number of interventional local ablative tumor treatments as a typical example of an oncological intervention in our study remained stable with the start of the COVID-19 pandemic. In the second half of the year, the number of interventions increased even more compared to the previous year. Interestingly, up to 27 % more ablation procedures were performed in the pandemic years 2020 and 2021 compared to 2019. This may be due to the fact that the number of surgeries was significantly lower in surgical disciplines than in IR due to the cancellation of elective and major surgeries [22]. Therefore, it was postulated that it would take 45 weeks with an increase in the normal surgery volume of 20 % to catch up on the backlog of canceled surgeries [23]. In light of the limited surgical capacity, it makes sense to switch from surgical interventions to image-guided interventional radiology treatment methods. Shaida and Alexander et al., for example, report increased demand for local ablative therapies in radiology and the establishing of outpatient interventions due to a lack of capacity at their facility in England [24]. Increased demand for interventional radiology procedures consequently requires a transformation process. This raises the question regarding the extent to which the number of interventional radiology procedures can be expanded to eliminate gaps in care and also to be able to offer these minimally invasive patient-oriented methods outside of pandemic crises.

Our study has a number of limitations. First, the analysis is based on the number of interventions voluntarily documented in the quality registry. The registry includes a very comprehensive Germany-wide dataset with > 300 participating hospitals thus allowing conclusions about coverage and quality of care and statements about health care policy. Even though the data analysis here seems plausible, deviations regarding the encoded data and the actually rendered services and changes in data entry cannot be ruled out particularly during the turbulent times of the pandemic. Second, the evaluation is based on an aggregated set of data. Regional variations over the course of the pandemic with varying degrees of fluctuation in examination volume and the establishing of different levels of care were not separately taken into consideration. Third, as a result of the input screen of the registry, a differentiated analysis of the service spectrum in COVID-19 patients could not be performed [25–27].

Conclusion

Based on the data in the quality registry of the German Society for Interventional Radiology and Minimally Invasive Therapy, our analysis provides an overview of the effect of the COVID-19

pandemic on IR services in Germany. The rapid recovery of the number of interventions after a temporary decrease during the first wave of the pandemic reflects the adaptability of IR and its importance in clinical care. The lessons learned from the pandemic should encourage the further development of the major potential of IR in Germany.

CLINICAL RELEVANCE OF THE STUDY

- Interventional radiology is an essential part of the therapeutic care of patients even during the COVID-19 pandemic.
- The increasing number of interventions in interventional oncology indicates that care shortages in surgical disciplines were able to be offset.
- Based on the data in the comprehensive quality registry of the German Society for Interventional Radiology and Minimally Invasive Therapy, this study helps to provide a better understanding of the effects of the ongoing COVID-19 pandemic on medical care.
- The results of this study can support measures to better adapt to future crises.

Conflict of Interest

The authors declare that they have no conflict of interest.

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