The Increased Mortality Rate with Lower Incidence of Traumatic Brain Injury during the COVID-19 Pandemic: A National Study

Grzegorz Miękisiak 1,*, Dariusz Szarek 2, Samuel D. Pettersson 3, Celina Pezowicz 4, Piotr Morasiewicz 1, Łukasz Kubaszewski 5 and Tomasz Szmuda 3

1 Institute of Medicine, University of Opole, 45-040 Opole, Poland
2 Department of Neurosurgery, Marciniak’s Hospital, 54-049 Wrocław, Poland
3 Department of Neurosurgery, Medical University of Gdansk, 80-210 Gdansk, Poland
4 Department of Mechanics, Materials and Biomedical Engineering, Faculty of Mechanical Engineering, Wrocław University of Science and Technology, Łukasiewicza 7/9, 50-371 Wrocław, Poland
5 Adult Spine Orthopaedics Department, Poznan University of Medical Sciences, 61-545 Poznan, Poland

* Correspondence: gmiekisiak@gmail.com

Abstract: Background: the COVID-19 pandemic with the following lockdown strategies have affected virtually all aspects of everyday life. Health services all over the world faced the crisis on an unprecedented scale, hampering timely care delivery. The present study was designed to assess the impact of the COVID-19 outbreak on the incidence and treatment of traumatic brain injuries in Poland. Methods: the data on hospital admissions with traumatic brain injuries as the primary diagnosis were extracted from the National Health Fund of Poland. For the purpose of this study, the search was limited to four relevant diagnosis-related groups. The overall in-house mortality was calculated. Results: there were 115,200 hospitalizations due to traumatic brain injury identified in the database. Overall, in comparison with the average of six prior years, in 2020 the volume of patients with traumatic brain injury dropped by 24.68% while the in-house mortality rate was increased by 26.75%. Conclusions: the COVID-19 pandemic with the resulting lockdown caused a radical reduction in human mobility. It had a profound impact on the incidence of traumatic brain injury, which dropped significantly. At the same time, the mortality rate increased drastically.

Keywords: traumatic brain injury; head trauma; COVID-19; mortality; lockdown

1. Introduction

Traumatic brain injury (TBI) is one of the leading causes of permanent disability worldwide [1]. It is sometimes referred to as a silent epidemic [2] and its incidence is still growing. Each year, an estimated 69 million individuals will suffer a TBI worldwide [3] with an estimated incidence of severe TBI of 73 cases per 100,000 people [4]. TBIs require multidisciplinary approaches and constitute a significant burden for all healthcare systems, regardless of socioeconomic status. The timely and effective prehospital as well as in-hospital treatment by qualified multidisciplinary teams is imperative to reduce mortality and morbidity [5]. This requirement makes it particularly reliant on efficient and robust emergency medical care, which was heavily affected by the recent COVID-19 pandemic.

It has already been shown that this unprecedented global outbreak profoundly impacted the management of neurosurgical patients. According to a recent study by Jean et al. [6], the volume of neurosurgical operations has dropped by more than 50% globally since the onset of the pandemic. As health services worldwide were inundated with infectious cases, most non-emergency procedures were deferred [7]. In March 2020, the American College of Surgeons issued prodigious recommendations to, among other things, “reschedule elective surgeries as necessary, and shift elective, urgent inpatient diagnostic and surgical procedures to outpatient settings, when feasible” [8].
The lockdowns have changed the behavior of the population on an unparalleled scale. This, in turn, affected the pattern of trauma, including TBI. It has been reported that lower mobility due to the pandemic resulted in a lower rate of road traffic accidents [9], but on the other hand, the incidence of violence-related TBIs increased [10].

This work aimed to assess the combined effect of the limited capacity of acute healthcare and altered patterns of trauma on the overall immediate outcomes of TBI treatment during the COVID-19 pandemic. This was accomplished by evaluating the national report on all patients treated for this particular type of injury in Poland for six consecutive years, from 2015 to 2020. The emphasis was on analyzing demographics, general volume, and in-house mortality. The main research question was whether the limited access to acute neurosurgical services was a more robust outcome factor than the purported decreased incidence of trauma overall.

2. Materials and Methods

2.1. Background

Poland is located in central and eastern Europe, with a population of 38,162,000 [11]. According to the World Bank, it is considered a high-income country [12]. The source of data for this study was the National Health Fund of Poland (Narodowy Fundusz Zdrowia—NFZ), which manages healthcare in Poland and is financed by compulsory health insurance contributions. In the last 14 years, NFZ has been using diagnosis-related groups for reimbursement. The pertaining data are regularly published on an official website [13]. The data used in this study covered all hospitalizations, with the TBI as a primary diagnosis funded by the National Health Fund within the period of 1 January 2015–31 December 2020. The latter year was representative of the pandemic lockdown. The following reimbursement groups were analyzed: A01—TBIs treated surgically and A76—TBIs managed conservatively. In 2018, two groups were added: PZA01 and P35, for minors under 18 treated respectively surgically or conservatively for TBI. The above groups cover all relevant hospitalizations. As TBIs are all treated in Poland within the public sector, the study covered all patients treated for TBI nationwide.

2.2. Study Design

This was a retrospective cohort study.

2.3. Participants

For the calculation of incidence, this work covers the entire population of Poland during the period specified above. The inclusion criterion was reimbursed hospitalization within A01, A76, PZA01 and P35 groups. There were no exclusion criteria. The sample size calculations for the population of 12,849 in 2020 revealed an error of 0.01% for the mortality rate.

2.4. Outcome Measures

In-house mortality, incidence.

2.5. Statistical Analysis

The significance of the changes in hospital admissions were calculated using the unadjusted Poisson regression model. The incidences were compared by calculating the z-ratio for the significance of the difference between two independent proportions [14,15]. Confidence intervals for proportions were calculated using the Wilson procedure without a correction for continuity [15]. The value of \( p < 0.05 \) was considered statistically significant.
The software used for statistical analyses were StatsDirect version 3.3.5 (StatsDirect Ltd., Merseyside, UK; http://www.statsdirect.com) and MedCalc v. 12.5.0.0 (MedCalc Software, Ostend, Belgium).

3. Results

During 2015–2020, a total of 115,200 hospitalizations were recorded. The overall number of TBI hospitalizations decreased in 2020 for both conservative and surgical management; the difference was statistically significant (Figure 1). In regard to diagnoses, significant differences were noted in the “surgical” group: there were fewer patients with subdural hematomas in favor of focal injuries and epidural hematomas (Table 1). Likewise, in the “conservative” group, a shift towards more severe conditions was noticeable (also Table 1). The breakdown of surgical procedures performed shows only minimal changes during 2020 against earlier years (Table 2). Although the age profile of patients was virtually unchanged in the “surgical” group, in a “conservative” group, the patient population was significantly older at \( p < 0.001 \) (Table 3). The most crucial finding was a statistically significant \( (p < 0.001) \) increase in the in-house mortality rate (Table 4). In either “surgical” and “conservative” groups, this value was increased in 2020, with, however, nearly identical total numbers of in-house deaths when comparing a sum from 2020 and mean per-annum from previous years. Overall, in comparison with the average of 6 prior years, in 2020 the volume of TBI patients dropped by 24.68% while the in-house mortality rate was increased by 26.75%.

Figure 1. Comparison of the annual TBI patient volume between the pre-COVID-19 period and 2020. ** \( p < 0.001 \).
Table 1. Diagnoses of hospitalized patients during the COVID-19 pandemic and preceding years according to the ICD 10 classification. * p < 0.05, ** p < 0.001.

| Diagnosis                              | ICD 10   | Surgical 2020 | %     | 2014–2019 | n  | %     | 2020 | %     | 2014–2019 | n  | %     |
|----------------------------------------|----------|---------------|-------|-----------|-----|-------|------|-------|-----------|-----|-------|
| Diffuse brain injury                   | S06.2    | 143           | 3.11  | 1109      | 0  | 0     | 0    | 0     | 0         |    |        |
| Focal brain injury                     | S06.3    | 87            | 1.89  | 837       | 0  | 0     | 0    | 0     | 0         |    |        |
| Epidural haemorrhage                   | S06.4    | 443           | 9.64  | 3643      | 0  | 0     | 0    | 0     | 0         |    |        |
| Traumatic subdural haemorrhage         | S06.5    | 3639          | 79.16 **  | 26113    | 8  | 3.84 ** | 1610 | 19.51 ** | 10241     | 14.95** |       |
| Traumatic subarachnoid hemorrhage      | S06.6    | 0             | 0     | 685       | 8  | 8.3 ** | 4011 | 5.85 ** |           |    |        |
| Cranial vault fracture                 | S02.0    | 0             | 0     | 1464      | 17| 17.49 ** | 7667 | 11.19 ** |           |    |        |
| Skull base fracture                    | S02.1    | 0             | 0     | 2171      | 3| 3.28 ** | 3181 | 4.64 ** |           |    |        |
| Complex cranial fracture               | S02.7    | 0             | 0     | 374       | 4.53 * | 3535 | 5.16 * |       |           |    |        |
| Other                                  | -        | 285           | 6.2   | 2136      | 6.3| 6.31 | 2079 | 25.29 ** | 25889     | 37.79** |       |
| total                                  |          | 4597          | 100   | 33838     | 100|       | 8251 | 100    | 68514     | 100|       |

Table 2. Main surgical procedures during the COVID-19 pandemic and preceding years according to the ICD 9 classification.

| Surgical Procedure                        |         | 2020       | %     | 2014–2019 | n  | %     |
|-------------------------------------------|---------|------------|-------|-----------|-----|-------|
| Burr hole                                 | 01.243  | 1728       | 34.26 | 12222     | 34.15 |       |
| 01.092                                    |         |            |       |           |    |       |
| Craniotomy for epidural hematoma          | 01.245  | 545        | 10.8  | 4115      | 11.5 |       |
| Craniotomy for subdural hematoma          | 01.247  | 2510       | 49.76 | 17771     | 49.66 |       |
| Skull base fracture                       | 01.245  | 545        | 10.8  | 4115      | 11.5 |       |
| Other                                     | -       | 261        | 5.17  | 1677      | 4.69 |       |
| total                                     |         | 5044       | 100   | 35785     | 100 |       |

Table 3. Age of patients treated due to TBI between the pre-COVID-19 period and 2020. * p < 0.05, ** p < 0.001.

| Age Category | Surgical 2020 | %     | 2014–2019 | n  | %     | 2020 | %     | 2014–2019 | n  | %     | 2020 | %     | 2014–2019 | n  | %     |
|--------------|---------------|-------|-----------|-----|-------|------|-------|-----------|-----|-------|------|-------|-----------|-----|-------|
| under 18     | 84            | 1.83  | 729       | 2.15 | 1044 | 12.65 ** | 11736 | 17.13 ** |     |        |      |       |
| 18–40        | 582           | 12.66 | 4640      | 13.71 | 1643 | 19.91 ** | 16128 | 23.54 ** |     |        |      |       |
| 41–60        | 1235          | 27.3  | 9218      | 27.25 | 2148 | 26.03 * | 17036 | 24.86 * |     |        |      |       |
| 61–80        | 1808          | 39.33 * | 12.811 | 37.87 * | 2252 | 27.29 ** | 16073 | 23.46 ** |     |        |      |       |
| 80+          | 868           | 18.88 | 6435      | 19.02 | 1164 | 14.11 ** | 7541  | 11.01 ** |     |        |      |       |
| total        | 4597          | 100   | 33833     | 100  | 8251 | 100   | 68514 | 100     |     |        |      |       |
Table 4. Comparison of mortality between the pre-COVID-19 period and 2020. ** \( p < 0.001 \).

|                  | Surgical 2020 | Surgical 2014–2019 | Conservative 2020 | Conservative 2014–2019 | All 2020 | All 2014–2019 |
|------------------|--------------|--------------------|-------------------|------------------------|----------|---------------|
| N of deaths      | 1196         | 7675               | 560               | 3361                   | 1756     | 11,036        |
| Deaths per annum | 1196         | 1279.17            | 560               | 560.17                 | 1756     | 1839.34       |
| N of hospitalizations | 4597     | 33,833             | 8251              | 68,514                 | 12,848   | 102,347       |
| Mortality rate (CI95%) [%] | 26.02 (24.77–27.31) ** | 22.68 (22.24–23.13) ** | 6.79 (6.27–7.35) ** | 4.91 (4.75–5.07) ** | 13.68 (13.09–14.27) ** | 10.78 (10.59–10.97) ** |

4. Discussion

Poland was hit heavily by the recent COVID-19 pandemic, similarly to other countries in the region. On 4 March 2020 the first case of SARS-CoV-2 was registered and soon after, restrictions were introduced abruptly. On 12 March the government declared a national state of emergency, and three days later, the borders were closed. Lockdown rules were imposed and all citizens were required to stay at home unless necessary. On 20 March the authorities announced the introduction of an epidemic state in Poland. The restrictions were gradually raised beginning on 20 April. The second wave appeared in October and was much more severe than the first one. New rules were introduced again and remained in effect until the end of the year. According to official sources, there were 1,294,878 cases of SARS-CoV-2, with 28,554 deaths confirmed across the country [16]. The health service system was working near its maximum capacity from mid-March throughout the rest of that year.

The present study was designed to look at the national data, covering all TBI hospitalizations in the country during 2020 and 6 years prior. It revealed that the volume of TBI patients dropped significantly, by nearly 25%, during the COVID-19 pandemic. Other authors around the world have reported similar trends. A large study based on data from 85 trauma centers in the USA has shown that the early phases of the COVID-19 pandemic were associated with a 32.5% decrease in trauma patient volumes [17]. Another two articles from Austria [18] and Finland [19] have shown a significant reduction in the incidence of TBIs. The meta-analysis, totaling 18,490 patients from 13 studies, came to the same conclusion [10]. The primary rationale for the finding is believed to be the lockdown and the stay-at-home strategies during the pandemic, which significantly reduced foot and vehicle traffic [20–23], as the leading cause of TBI in Poland [24] is motor vehicle accidents. In a recent article by Johnson et al. [25] the authors further dissected the data on the incidence of TBIs during the pandemic. They found that the 18% decrease in the rate of TBI-related admissions was noted only during the first eight weeks of the lockdown, followed by a 16% increase during the last eight weeks. Cumulatively, there was no difference between the pre-pandemic and pandemic periods.

The epidemiology of other neurologic conditions, such as stroke, were also affected. During the COVID-19 period, the overall number of hospitalizations due to stroke in Poland dropped by 8.28% compared with the corresponding period of 2019 [26]. Other authors reported similar findings, with the highest drop of 39.52% during the critical period recorded in Spain [27]. The primary factor behind these findings is poor access to emergency medical services and fear of contracting the virus rather than changes in incidence [28]. The lockdown due to COVID-19 pandemic greatly restricted the mobility of entire populations, which turned into a significant decrease in the incidence of trauma worldwide [29], including the pediatric population [30].

The patient demographics changed during 2020. The patient population was significantly older, but only in the “conservative” group. This may be related to the change in the mechanisms of injury: the second most common cause of TBI is falls [24] and they primarily affect the elderly, the leading cause of death for persons 65 years of age or older [31,32].
The most prevalent diagnosis in both groups was subdural hemorrhage, with a small but significant increase in incidence in 2020. A similar finding was reported by Lara-Reyna [33]. On the contrary, a study from the Czech Republic and Austria showed no difference in all subgroups of patients treated for TBIs [34].

The COVID-19 pandemic profoundly affected the entire health system, and neurosurgery was not exempt. The survey study among neurosurgeons around the world by Jean et al. [6] has shown that nearly half of the respondents (46.1%) reported that their operative volume had dropped more than 50% during the pandemic. The drop was caused primarily by the postponement of all non-urgent operations that did not require urgent or emergent intervention [21]. However, patients with common time-sensitive medical and surgical emergencies, such as TBI, were to receive the necessary treatment without delay. Official recommendations were [35] established [8] to maintain the emergency care system. The authors of two studies [23,34] concerned with the non-elective neurosurgical procedures in central and eastern Europe have shown no difference in volume during the pandemic.

The key finding of this study is a significant increase in the mortality rate. In 2020 this value increased by nearly one-third, from 10.78% to 13.67%. This finding was replicated in two studies from India [36,37] but not in articles from Germany [38] or Ireland [39]. Most notably, the recent meta-analysis [10] has shown that mortality was increased only in low- to middle-income countries. As a high-income country, Poland may be a disturbing exception to this rule.

The treatment of TBI is immensely complex, and many factors affect the overall outcome. The available dataset does not provide a clear rationale for this finding. One plausible explanation for the increased mortality is the critical shortage of acute beds in ICUs [40], which were overburdened with COVID-19 patients requiring prolonged ventilation. Another problem of TBI care during pandemics was noticed by Manivannan et al., who found that a more significant proportion of patients are being managed locally in non-neurosurgical units in order to minimize the risk of COVID-19 spread between hospitals [41]. Regardless of the rationale, some 300 surplus in-house deaths were due to TBI in 2020 alone. As the total number of deaths did not change from previous years, it does not contribute to the widely reported [42] excessive all-causes mortality during pandemic.

5. Study Limitations

The present study is not without limitations. There were no available data on the mechanisms of TBI, which must have had a significant and demonstrable bearing on the outcomes. The severity of injury, a key prognostic factor, was also unobtainable. Mortality was the only reliable outcome measure given the available dataset, as information on discharge was very crude, not allowing for meaningful analysis. There was no available information on comorbidities nor concurrent drug therapies, which are both risk factors for mortality in COVID-19 patients in previous studies [43]. Last but not least, the data were pooled, and only predetermined statistics were available.

6. Conclusions

The COVID-19 pandemic and the subsequent lockdown caused an unparalleled reduction in human mobility. It had a profound impact on the incidence of TBI, which decreased by nearly 25% during COVID-19, while at the same time, the mortality rate increased by 26.75%, unlike in other high-income countries. The latter finding shows the necessity to change health policies during similar crises in the future.

Author Contributions: Conceptualization, G.M. and T.S.; methodology, S.D.P.; software, G.M.; validation, C.P., S.D.P. and E.K.; formal analysis, G.M. and S.D.P.; investigation, D.S.; resources, C.P.; data curation, P.M.; writing—original draft preparation, S.D.P., G.M. and D.S.; writing—review and editing, D.S.; visualization, C.P.; supervision, G.M. and T.S.; project administration, T.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.
Institutional Review Board Statement: Ethical review and approval were waived for this study, as the data used in this study were based on preexisting analyses.

Informed Consent Statement: Patient consent was waived due to the anonymous character of data analyzed retrospectively.

Data Availability Statement: Original data were obtained from the official website of the NFZ, which is available in the public domain.

Conflicts of Interest: The authors declare no conflict of interest.

References
1. Brooks, J.C.; Strauss, D.J.; Shavelle, R.M.; Paculdo, D.R.; Hammond, F.M.; Harrison-Felix, C.L. Long-Term Disability and Survival in Traumatic Brain Injury: Results from the National Institute on Disability and Rehabilitation Research Model Systems. Arch. Phys. Med. Rehabil. 2013, 94, 2203–2209. [CrossRef] [PubMed]
2. Alkhairbary, A.; Alshalawi, A.; Althaqafi, R.M.; Alghuraybi, A.A.; Basalamah, A.; Shammar, A.M.; Altalhy, A.A.; Abelrahman, T.M. Traumatic Brain Injury: A Perspective on the Silent Epidemic. Cureus 2021, 13, e15318. [CrossRef]
3. Dewan, M.C.; Rattani, A.; Gupta, S.; Baticulon, R.E.; Hung, Y.C.; Punchak, M.; Agrawal, A.; Adeleye, A.O.; Shrive, M.G.; Rubiano, A.M.; et al. Estimating the Global Incidence of Traumatic Brain Injury. J. Neurosurg. 2019, 130, 1080–1097. [CrossRef] [PubMed]
4. Iaccarino, C.; Carretta, A.; Nicolosi, F.; Morselli, C. Epidemiology of Severe Traumatic Brain Injury. J. Neurosurg. Sci. 2018, 62, 535–541. [CrossRef] [PubMed]
5. Chuck, C.C.; Martin, T.J.; Kalagara, R.; Shaaya, E.; Kheirbek, T.; Cielo, D. Emergency Medical Services Protocols for Traumatic Brain Injury in the United States: A Call for Standardization. Injury 2021, 52, 1145–1150. [CrossRef]
6. Jean, W.C.; Ironside, N.T.; Sack, K.D.; Felbaum, D.R.; Syed, H.R. The Impact of COVID-19 on Neurosurgeons and the Strategy for Triaging Non-Emrgent Operations: A Global Neurosurgery Study. Acta. Neurochir. 2020, 162, 1229–1240. [CrossRef]
7. Chang, D.; Xu, H.; Rebaza, A.; Sharma, L.; dela Cruz, C.S. Protecting Health-Care Workers from Subclinical Coronavirus Infection. Lancet Respir. Med. 2020, 8, e13. [CrossRef]
8. COVID-19: Recommendations for Management of Elective Surgical Procedures | ACS. Available online: https://www.facs.org/for-medical-professionals/covid-19/clinical-guidance/elective-surgery/ (accessed on 20 September 2022).
9. Rault, F.; Terrier, L.; Leclerc, A.; Gilard, V.; Emery, E.; Derrey, S.; Briant, A.R.; Gakuba, C.; Gaberel, T. Decreased Number of Deaths Related to Severe Traumatic Brain Injury in Intensive Care Unit during the First Lockdown in Normandy: At Least One Positive Side Effect of the COVID-19 Pandemic. Acta. Neurochir. 2021, 163, 1829–1836. [CrossRef]
10. Damara, F.A.; Muchamad, G.R.; Anton, A.; Ramdhani, A.N.; Channel, I.C.; Faried, A. Epidemiological Pattern of Traumatic Brain Injury in the COVID-19 Pandemic: A Systematic Review and Meta-Analysis. World Neurosurg. 2022, 161, e698. [CrossRef]
11. Główny Urząd Statystyczny/Obszary Tematyczne/Ludność/Ludność/Rezydenci (Ludność Rezydująca). Available online: https://stat.gov.pl/obszary-tematyczne/ludnosci/ludnosci-stan-i-struktura-ludnosci-oraz-ruch-naturalny-w-przekroju-terytorialnym-stan-w-dniu-30-06-2021,6,30.html (accessed on 21 September 2022).
12. WDI—The World by Income and Region. Available online: https://datatopics.worldbank.org/world-development-indicators/the-world-by-income-and-region.html (accessed on 21 September 2022).
13. Narodowy Fundusz Zdrowia Statystyka NFZ. Available online: https://statystyki.nfz.gov.pl/ (accessed on 31 August 2021).
14. Lowry, R. Significance of the Difference Between Two Independent Proportions. Available online: http://vassarstats.net/propdiff_ind.html (accessed on 21 September 2022).
15. Julious, S.A. Two-Sided Confidence Intervals for the Single Proportion: Comparison of Seven Methods. Stat. Med. 2005, 24, 3383–3384. [CrossRef] [PubMed]
16. MZ Raport Zakaz Konarowirusem (SARS-CoV-2)–Konarowirus: Informacje i Zalecenia-Portal Gov.Pl. Available online: https://www.gov.pl/web/koronawirus/wykaz-zarazen-koronawirusem-sars-cov-2 (accessed on 31 August 2021).
17. Berg, G.M.; Wyse, R.J.; Morse, J.L.; Chipko, J.; Garland, J.M.; Slivinski, A.; Lieser, M.; Biswas, S.; Carrick, M.M.; Rhodes, H.; et al. Decreased Adult Trauma Admission Volumes and Changing Injury Patterns during the COVID-19 Pandemic at 85 Trauma Centers in a Multistate Healthcare System. Trauma. Surg. Acute. Care. Open 2021, 6, e000642. [CrossRef] [PubMed]
18. Pinggera, D.; Klein, B.; Thomé, C.; Grassner, L. The Influence of the COVID-19 Pandemic on Traumatic Brain Injuries in Tyrol: Experiences from a State under Lockdown. Eur. J. Trauma Emerg. Surg. 2020, 47, 653–658. [CrossRef]
19. Luostarinen, T.; Virta, J.; Satopää, J.; Bäcklund, M.; Kivisaari, R.; Korja, M.; Raj, R. Intensive Care of Traumatic Brain Injury and Aneurysmal Subarachnoid Hemorrhage in Helsinki during the Covid-19 Pandemic. Acta Neurochir. 2020, 162, 2715–2724. [CrossRef] [PubMed]
20. Figueroa, J.M.; Boddu, J.; Kader, M.; Berry, K.; Kumar, V.; Ayala, V.; Vanni, S.; Jagid, J. The Effects of Lockdown During the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) Pandemic on Neurotrauma-Related Hospital Admissions. World Neurosurg. 2021, 146, e1. [CrossRef] [PubMed]
21. Ozoner, B.; Gungor, A.; Hasanov, T.; Toktas, Z.O.; Kilic, T. Neurosurgical Practice During Coronavirus Disease 2019 (COVID-19) Pandemic. World Neurosurg. 2020, 140, 198. [CrossRef] [PubMed]
