Travmatik Beyin Hasarli Çocuk Hastalarda Tekrarlayan Bilgisayarli Tomografinin Değerliliği ve Radyasyon Hasari*

Value of Repeated Computed Tomography and Radiation Exposure in Pediatric Patients with Traumatic Brain Injury

***Mustafa YAZICIOĞLU*[1]**

***Doğaç Niyazi ÖZÜÇELİK*[2]**

***Barış Murat AYVACI*[1]**

***Derya ÖZAŞIR*[1]**

***Yılmaz AYDIN*[1]**

***Uyarış ÇOBAN*[1]**

***Halil DOĞAN*[1]**

[1]*Bakırköy Sadi Konuk Eğitim ve Araştırma Hastanesi*
[2]*İstanbul Üniversitesi Sağlık Bilimleri Fakültesi*

Yazışma adresi/ Coresspondence
Derya Özaşır, Bakırköy Sadi Konuk Eğitim ve Araştırma Hastanesi, deryaozasir@gmail.com

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Özet

Amaç: Bu çalışma, Travmatik Beyin Hasarı olan çocuklarda tekrarlayan BT çekimlerinin gerekli bir uygulama olup olmadığını araştırmak amacıyla planlanmıştır. **Gereç ve Yöntemler:**31 Aralık 2009-31 Aralık 2010 tarihleri arasında etik kurul onayı sonrası Bakırköy Sadi Konuk Eğitim ve Araştırma Hastanesine başvuran ve kafa travması nedeniyle hastaneye yatırılarak tekrarlayan Bilgisayarlı Tomografi (BT) çekilen, 16 yaş ve altı 76 hasta geriye dönük olarak incelenmiştir. Elde edilen veriler, SPSS for Windows 15 istatistik programına kaydedilerek istatistiksel analizleri yapılmıştır. **Bulgular:** Araştırmaya alınan 76 hastanın 51'i (% 67,1) erkek, 25'i (%32,9) kız ve yaş ortalamaları 5,82 ± 3,66 bulundu. Araştırmaya alınan 76 hastaya toplamda 317 kez BT çekilmişti. Hastaların %42,10'una üç BT çekilirken geri kalanına üçten fazla BT çekilmişti. Hastaların %78,94'ünün sekelsiz taburcu olduğu, %7,9'unun opere edildiği görüldü. Hastaların ikinci BT'lerinde birinci BT'lerine göre sadece 2 hastada değişiklik saptandığı, yeni gelişen lezyon olarak bir hastada epidural hematom ve bir hastada subdural hematomun ortaya çıktığı belirlendi. Birinci BT sonuçlarına göre hastaların %7.9'una cerrahi tedavi uyulandı. Hastaların %92.1'i herhangi bir cerrahi tedavi uygulanmadan hastaneden taburcu oldu. Hastaların %6.6'sı sekelli iyileşirken, mortalite oranı %1.3 olarak bulundu. Tekrarlayan BT'ler ile çocuklara ek radyasyon dozu verilirken, tedavilerinde herhangi bir değişiklik oluşmadı. **Sonuç:** Kafa travmalı çocuklarda tekrarlayan BT'lerin hastanın prognozuna, acil cerrahi girişim ve tahmini yaşam beklentisine bir katkısı olmadığı tespit edilmiştir. Tekrarlayan BT çekimi uygulanan çocuklar, gelecekte radyasyon ile ilişkili gelişebilecek hastalıklar yönünden izlenmelidir.

Anahtar kelimeler: Çocuklarda kafa travması, tekrarlayan beyin BT, radyasyon, travmatik beyin hasarı

***Makale Dr. Mustafa Yazıcıoğlu'nun ''Kafa Travmalı Çocuklarda Tekrarlayan BT Kullanımının Değerliliği''adlı uzmanlık tezinden oluşturulmuştur**

Abstract

Aim: The aim of this study is to investigate the necessity of repeated computed tomography **(**CT) in pediatric patients with Traumatic Brain Injury (TBI). **Materials and Methods:** After ethical committee approval **,**this retrospective study was done between 76 pediatric patients with age ≤ 16 who applied to Bakirkoy Dr.Sadi Konuk Education and Research Hospital in between 31 December 2009- 31 December 2010 due to Head Trauma. **Results**: Fifty one of 76 patients were male, 25 were female and average age was 5.82±3.66. Of the patients admitted to emergency department, 86.84% have mild TBI, 7.9% have moderate TBI and 5.62% have severe TBI pre-diagnosis. Forty two point one percent of patients had CT three times, the rest had more than three times; total CT number was 317. Two patients showed changes in second CT (one epidural and one subdural hemorrhage) according to first CT whereas there was no change in third CT. The decision of operation in all operated patients treated surgically (7.9%) was given according to the result of first CT. While 92.1% of patients were discharged from the hospital by complete recovery, 6.6% of patients were with sequelae and mortality ratio was 1.3%. The changes in repeated CT did not change the treatment while every child was exposed to additional radiation. **Conclusion**: Repeated CT in children with head trauma did not contribute to the prognosis of patients, the choice of treatment and survival. The children applied serial CT should be followed for the diseases which can be progressed due to radiation in future.

Key words: Head trauma in children, repeated brain CT, radiation exposure, traumatic brain injury

Introduction

Traumatic Brain Injury (TBI) is one of the most important diseases of 21. century which causes mortality and disablement (1,2). Different procedures about the indication, dosage of Head CT and repeated CT used common in pediatric TBI have been performed in different centers (3-4).

The rates of CT used in the USA and other countries have increased rapidly particularly in the past 10 years (5). The use of CT procedures has expanded to more than 70 million in the United States per year, with nearly 10% of procedures performed on children (6).

Although CT scans are very useful clinically, recent reports have raised concerns about the potential for malignancy following CT scanning, especially in pediatric patients (5) In a case-control study (part of the UK Childhood Cancer Study) by Rajaraman et al.
was showed further evidence of possible excess risk of cancer, even at doses lower than those associated with CT scanning (7). However, recent studies have challenged the need for a routine second or serial brain CT study after TBI.

The aim of this study to investigate the necessity of repeated CT which causes additional radiation exposure in pediatric patients.

Materials and methods

Of 167 pediatric patients admitted to Emergency Department of Bakirkoy Dr. Sadi Konuk Training and Research Hospital in between 01 January 2010 -31 December 2010, followed and having CT more than once, 76 patients with ages ≤ 16 with TBI diagnosis were chosen

for the study. The patients having computed CT due to non-traumatic reasons and whose information could not be totally gathered were excluded from the study.

Brain CT screening was performed in 10 mm sections by tomography device of Siemens Somatom Sensation mark. The sections with the largest intracranial hemorrhage in brain CT were calculated in millimeter (mm) and recorded.

Statistical analysis was performed by using SPSS for Windows 15.0. Chi-square was used in proportional data. Non-parametric data were analyzed by Spearman Korelasyon. $p<0.05$ was considered as significant

Results

Sixty seven point one percent (41) of 76 patients were male and 32.9% (25) were female. The average age was calculated as 5.82 ± 3.66 (minimum: 1; maximum: 15). Twenty three point seven percent of the patients were in 0-2 age group, 39.5% of patients were in 3-7 age group, 28.9% of patients were in 8-12 age group and 7.9% of patients were in 13-16 age group.

In the admitted in emergency department (ED), while 85.5% of the patients were observed as conscious, 9.2% of patients were confused, 3.9% of patients were coma and 1.2% of patients was found lethargic. Pathology in other systems than head injuries were detected in 25% of patients.

Of the patients applied to ED, 86.9% have mild TBI (GCS 3-8), 7.9% have moderate TBI (GCS 9-13) and 5.2% have severe TBI pre-diagnosis (GCS 14-15). The relationship between admission and discharge GCS values and operation and recovery was summarized in Table 1.

Table 1. The Outcome of Patients Grouped According to the Degree of Brain Injury at the Time of Admission and Discharge

	Admission GCS n (%)	**Discharge GCS n (%)**	**Surgery (-) n (%)**	**Surgery (+) n (%)**	**Sequel (-) n (%)**	**Sequel (+) n (%)**
Severe TBI (GCS=3-8)	4 (5.2)	2 (2.6)	3 (4.3)	1 (16.6)	2 (2.8)	2 (40)
Moderate TBI (GCS=9-13)	6 (7.9)	0 (0)	5 (7.1)	1 (16.6)	6 (8.6)	0 (0)
Mild TBI (GCS=14-15)	66 (86.9)	74 (97.4)	62 (88.6)	4 (66.7)	62 (88.6)	4 (60)
Total	76 (100)	76 (100)	70 (100)	6 (100)	70 (100)	6 (100)
p	p<0.05		p>0.05		p<0.05	

In this study, total 317 times CT scan were applied to 76 patients (median: 4.17; minimum: 3; maximum: 11 CT). 58.9% of patients had CT more than third times. After computed CT screening, children were exposed to estimated 249162 mSv radiation (Table 2).

Any operation was not performed to 92.1% of patients applied computed CT.
Five of 6 (83.3%) patients operated and 65 of 70 (92.9%) patients not operated were discharged from the hospital by complete recovery. The difference between operation and recovery was found as statistically significant ($p<0.05$).

Table 2. Estimated Radiation Dose That the Patients Were Exposed

	n	**CT/patient**	**Estimated Radiation dose/patient**	**Total CT number**	**Estimated Total Radiation dose**
Radiation dose (mSv)	32	3	48	96	4608
	19	4	72	76	5472
	15	5	90	75	6750
	5	6	108	30	3240
	3	7	126	21	2646
	1	8	144	8	1152
	1	11	198	11	2178
Total	76	44	786	317	249162

The estimated radiation dose per one cranial CT is 18 mGy=18 mSv

While the operation decision of patients treated surgically was given due to first CT, repeated CT treatment form was not changed. One patient not operated was exitus after 24 hours (mortality rate was 1.3%).

Seventy six patients accepted to the study showed totally 94 lesions in their CTs (Table 3). The indications of most surgical operations in all patients were reported in the patients with depressed fracture of their CTs, most progression with sequelae were detected in the patients with SDH in their CTs. Differences between patients in both groups were statistically different ($p<0.05$).

Two of 37 patients who had hemorrhage in first CT (5.4%) also showed new hemorrhage in second CT (epidural hemorrhage in one patient and subdural hemorrhage in other one) and they were not treated emergent surgically and were discharged with sequelae. None of the patients who did not have hemorrhage in second CT have no new hemorrhage in third CT ($p=1.000$).

While 84.61% of 39 patients who had hemorrhage in first CT were discharged with sequelae (one patient was exitus and five patients were sequel), 100% of 37 patients who did not have hemorrhage in first CT were discharged without sequelae ($p=0.013$).

Hemorrhage thickness of patients in first CT, second CT and third CT mean were reported as 3.29 mm ± 4.31 (minimum: 0 - maximum: 21 mm); 3.61 mm ± 4,79 (minimum: 0 - maximum: 23 mm); 3.57 mm ± 4.72 (minimum: 0 - maximum: 23 mm) respectively.

Table 3. CT Findings and the Number of Patients Treated Surgically

CT Findings	**1st CT (n)**	**2nd CT (n)**	**3rd CT (n)**	**Surgery (+)**	**Surgery (-)**	**p**	**Sequel (+)**	**Sequel (-)**	**p**
Linear fracture	40	40	40	3	37	p>0.05	**1**	39	p>0.05
EDH	23	**24**	24	2	22	p>0.05	**1**	23	p>0.05
SDH	12	**13**	13	1	12	p>0.05	**4**	9	**p<0.05**
Compression fracture	11	11	11	3	8	**p<0.05**	**2**	9	p>0.05
ICH	3	3	3	1	2	p>0.05	0	3	p>0.05
Contusion	2	2	2	-	2	p>0.05	**1**	1	p>0.05
SAH	1	1	1	-	1	p>0.05	0	1	p>0.05

EDH: Epidural hemorrhage; SDH: Subdural hemorrhage; ICH: Intracranial hemorrhage; SAH: Subarachnoid hemorrhage.

Eighteen point four percent of the patients showed increase in hemorrhage volume in the second CT according to first CT while 10.5% had decreased volume in hemorrhage. Nine point two percent of patients showed increase in hemorrhage volume in third CT according to second CT while 15.8% had decreased hemorrhage volume.

In patients, 0.32 mm increase between average measurements of first CT and second CT hemorrhage were found as statistically significant ($p<0.05$). Moreover, there was a significant correlation between changes in hemorrhage measurements of second CT in patients and GCS changes during observation (Spearman Korelasyon, $p=0.047$).

Discussion

In recent studies, the need for a routine second or serial brain CT study after TBI have begun to discuss in pediatric patients because of concerns about the potential for malignancy. In this study, the necessity of repeated CT application in the patients with pre-diagnosed of TBI was investigated.

While of the patients applied to ED by pediatric head trauma, 65-70.1% has mild TBI, 17.1-27.9% has moderate TBI and 6.8-6.9% has severe TBI (8-9) our study showed that 86.9% of the patients having repeated CT had mild TBI.

In the studies about pediatric head trauma, a strong relationship was reported between low GCS and worse CT and worse negative patient results (10-11). A study of Fearnside et al. reported that 65% of patients with 3 GCS score and 10% of patients with 7-13 GCS score ended with mortality (12). In our study, while GCS levels of patients in admission decreased,

the rate of surgical operations (severe: 6.1%, modarate: 25%, mild: 25%) and the rate of recovery with sequelae increased (mild: 6.1%, moderate: 0% and severe: 50%).

While there are no guidelines the necessity of repeat CT scan after TBI, to define progressive lesions required surgical operations, in some studies routine repeated CT was reported not to have advantage in the patients with head trauma (13-14-15).

In a study, out of 47 children, 5 (11%) underwent neurosurgical intervention following their second imaging study. They said that serial brain imaging may not be required for all children with intracranial injury (13). In a retrospectively study, One hundred and seventy-four patients were enrolled, fifty-four patients (31%) had pathological CT findings, eight patients underwent neurosurgical treatments. They believe that even though CT scans may be clinically unnecessary in many cases (15). In the study of Lee et al. (14) 77.9% of patients with decrease in GCS score had worse results in CTs, thus repeated CT screening is suggested for retrogressed clinical situations in patients. In the study of Brown et al., although there was neurological findings showed no retrogression, CT was suggested to be applied to the head traumatic patients with GCS score of eight and less (16). In this study, the significant correlation between GCS changes in patients' progression and changes in CT showed that clinical observation and GCS monitoring of the patients prevent repeated CT application and unnecessary radiation exposure.

In a study of Stone et al., an increase in subdural hematoma volume increased the patient mortality (17). In other study of Zumkeller et al., survival rate was reported as 50% in comatose patients with 18 mm subdural hematoma thickness and 20 mm middle line shift (18). In a study of Servadei et al., sizes of lesions decreased in 15 of 37 patients in first 12 hours while 22 showed increase in lesion sizes (19). In this study, in contrast to the literature, changes in hemorrhage thickness of CT (between zero and 23 mm) did not affect the operation-non-operation decision and the progression process with and without sequelae of patients.

In the studies with pediatric head trauma and serial CT, of the patients 9-16% showed epidural hemorrhage (EDH), 4.28-40% showed subdural hemorrhage (SDH), 1-57% showed intracranial hemorrhage (ICH), 6.04-64% showed subarachnoid hemorrhage (SAH), 8.5-38% showed contusion, 37.5% showed linear fracture, 7% showed depression fracture (10, 20, 21, 22). Durham et al. reported that repeated CT screening is suggested in children with high risk lesions with EDH, SDH, cerebral edema and ICH while this screening was emphasized to have limited advantages in patients with SAH, ICH and isolated head fractures unless there is deterioration in clinical situation of patients and the evaluation of risks in radiation exposure is necessary (23). In this study, while linear fracture, depression fracture and EDH were observed more frequently than in other studies, the frequencies of SDH, ICH, contusion and SAH were same as in other studies. Our study indicated that 97.4% of the patients of second CT was same with first CT, 100% of third CR was same with second CT and two new hemorrhage detected in second CT of the patients did not change the treatment process. Thus, this showed that repeated CT is not necessary for these patients.

In a study by Murgio et al. (24), 7.83% of the patients with head trauma were operated surgically while 18.2% of the patients in a study by Simsek et al (9) were operated surgically. In a study by Isik et al. (25), 89.2% of patients were shown total recovery, 7% was discharged

by sequelae and the mortality rate was reported as 3.8%. Figg et al reported that the emergent operations were applied to the patients with serious TBI in repeated CT screening and only with increased intracranial pressure (21%) and deterioration in neurological findings (3%) (26). They also reported that emergent operation application is not necessary for the patients who had CT screening without any routine findings. In this study, surgical operation was applied to 7.9% of patients, of these 92.1% of the patients showed total recovery, 6.58% was discharged by sequelae and mortality rate was 1.31%.

Also this study showed that the operation decision was given according to first CT result and sequential CTs do not affect the treatment process of the patient. Thus this revealed that repeated CTs were not necessary for the patients admitted to this study.

CT, the initial screening tool for head traumas includes high dose radiation (7-27). Before giving the decision about usage of CT screening, clinical observations for especially minor head traumatic children have decreased unnecessary ionic radiation exposure and long term risks (28).

CT screening was applied three times to 42.4% of the patients admitted to this study and the last as more than three times. While new findings raised from repeated CTs in the study did not affect diagnosis and prognosis of the patients, every child was exposed to 36 mSv additional radiation and all children were exposed to estimated 248372 mSv additional radiations totally due to repeated CT.

This study showed that the severity of GCS in admission and first CT lesion was important for closed monitoring and diagnosis process in patients. Also GCS and closed clinical observation in the pediatric patients with minor traumatic head trauma are enough. Repeated CTs without and changes in these findings have not affected the treatment process of patients and caused additional radiation exposure. Moreover, this research revealed that clinicians and radiologists should be definitely in contact for radiological screening of pediatric patients.

Conclusion

Repeated CT screening performed in pediatric patients with traumatic brain injury has not contributed to the prognosis of the patients, emergency treatment choice, recovery process without sequelae and survival. Due to repeated CTs, additional radiation exposure to pediatric patients poses a risk for radiation based cancers in future. These children should be monitored closely for progressive diseases.

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