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Original Article *Özgün Araştırma*

TRACTOR RELATED DEATHS (ROLLOVER, FALL, ACCIDENT, LIGHTNING STRIKE)

Traktör İlişkili Ölümler (Devrilme, Düşme, Kaza, Yıldırım Çarpması)

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ABSTRACT

Objective: Tractor-related accidents are more common than other agricultural vehicles. Tractor overturning is one of the major risk factors for farmers. In this study, it was aimed to discuss the sociodemographic characteristics, autopsy findings, the cause of death and measures to be taken of the tractor-related deaths with literatüre.

Material and Methods: In this study, reports of tractor-related deaths were investigated retrospectively in cases where an autopsy was performed in the Morgue Department of Istanbul Council of Forensic Medicine between 2008 and 2012.

Results: It was determined that 42 (0.2%) of 20,559 cases who were autopsied in Istanbul between 2008-2012 were tractor-related deaths. Thirty-eight (90.5%) of the cases were male and four cases (9.5%) were female. The average age was 44.54±20.66 (min: 2, max: 80) with the most common death occurring at 60 years and above. Twenty-six (61.9%) of the cases were drivers. The most common death occurred in July and November (n: 7, 16.6%). The death occurred due to tractor overturns in 50% of the cases (n: 21), whereas the reason for death was falling from the tractor in 31% (n=13), traffic accident in 7.1% (n=3), run-over in 7.1% (n=3) and lightning strikes in 4.8% (n=2).

Conclusion: In the prevention of tractor-related deaths, is necessary to prohibit the use of tractors as a means of transport and increase the use of seat belts and roll-over protective structures (ROPS) in all tractors.

***Keywords**: Death, accident, rollover, forensic medicine.*

ÖZ

Amaç: Diğer tarım araçlarına göre traktör ilişkili kazalara daha sık rastlanmaktadır. Tarımcılar için traktör devrilmesi majör risk faktörlerinden birisidir. Bu çalışmada traktörle ilgili olarak meydana gelen ölümlerin sosyodemografik özellikleri, otopsi bulguları, ölüm sebebi, önlenmesi açısından alınması gereken önlemlerin literatür ışığında tartışılması amaçlanmıştır.

Gereç ve Yöntemler: Çalışmada 2008-2012 tarihleri arasında İstanbul Adli Tıp Kurumu Morg İhtisas Dairesi'nde otopsisi yapılan olgularda traktör ilişkili ölümlerin otopsi raporları retrospektif olarak incelenmiştir.

Bulgular: İstanbul'da 2008-2012 yılları arasında otopsi yapılan 20,559 olgunun 42'sinin (%0.2) traktör ile ilgili ölüm olduğu tespit edilmiştir. Olguların 38'i (%90.5) erkek, dördü (%9.5) kadın cinsiyettir. Yaş ortalaması 44.54±20.66 (min:2, max:80) olup, en sık 60 yaş ve üzeri (n=13, %31) yaş grubunda ölüm gerçekleştiği belirlenmiştir. En sık ölüm Temmuz ve Kasım aylarında (n=7, %16.6) gerçekleşmiştir. Olguların %50'sinde (n=21) traktör devrilmesi, %31'inde (n=13) traktörden düşme, üçünde (%7.1) trafik kazası, üçünde (%7.1) ezilme ve ikisinde de (%4.8) yıldırım çarpması nedeniyle ölüm gerçekleşmiştir.

Sonuç: Traktör kazalarının önlenmesinde traktörlerin taşıma aracı olarak kullanılmasının önlenmesi, sürücülerin emniyet kemeri kullanması ve traktör devrilmesini önleyici sistemlerin kullanılması faydalı olacağı düşünülmektedir.

***Anahtar Kelimeler**: Traktör, ölüm, kaza, devrilme; adli tıp*

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INTRODUCTION

The tractor is used as a farming tool and it is also used as a transportation vehicle especially in rural areas. The majority of deaths related to agriculture depend on vehicles used in agriculture and tractor-related deaths are the most common among these vehicles (1). Tractors, large, heavy, and powerful vehicles with a high center of gravity, can tip over when used by inexperienced and untrained people on sloping, irregular, or slippery land (2). As a result of the tractor tipping over, it is inevitable that serious injuries or even death occur if the roll-over protection system and seat belt are absent (3). The tractor produced for use in agriculture is also frequently used as a means of transportation, especially in rural areas of Turkey. Fatal injuries may occur due to falling or a traffic accident on tractors with no safety precautions for passengers other than the driver (4). Istanbul is the largest city in Turkey in terms of both population and economy. Although the industry is more prominent in Istanbul, 15% of the city's surface area is composed of agricultural areas, and agricultural efforts have increased in recent years. In this study, it was aimed to discuss the sociodemographic characteristics, autopsy findings, the cause of death and action to be taken of the tractor-related deaths with literature.

MATERIALS AND METHODS

In this study, reports of tractor-related deaths were investigated retrospectively in cases where the autopsy was performed in the Morgue Department of Istanbul Council of Forensic Medicine between 2008 and 2012.

The study was conducted in accordance with the principles of the Declaration of Helsinki. Ethics committee approval dated October 19, 2020, and numbered 427 was obtained from Bolu Abant Izzet Baysal University Clinical Research Ethics Committee for the study.

Cases were evaluated by age, gender, time of incident, scene, type of accident, trauma findings, and cause of death. SPSS 21.0 (Armonk, NY) statistics program was used for data analysis of the study. Descriptive statistics were presented with frequency, percentage, mean (mean), standard deviation (SD), minimum (min), maximum (max) values.

RESULTS

It was determined that 42 (0.2%) of 20,559 cases who were autopsied in Istanbul between 2008-2012 were tractor-related deaths. Thirty-eight (90.5%) of the cases were male and four (9.5%) were female. The average age was 44.54±20.66 years (min: 2, max: 80) and it was determined that the most frequent deaths occurred at the age of 60 and over (n=13, 31%) (Figure 1).

Twenty-six (61.9%) of the cases were drivers, 13 were passengers (30.9%) and three (7.2%) were pedestrians. The highest number of death occurred in July and November (n=7, 16.6%) and 73.8% (n=31) of deaths occurred in summer and autumn seasons (Figure 2). Death occured due to tractor overturning in 50% (n=21) of the cases, whereas the reason for death was falling from the tractor in 31% (n=13), traffic accident in three (7.1%), crushing in three (7.1%) of the cases and in two cases (%4.8) death was occurred due to lightning strike (Table 1).

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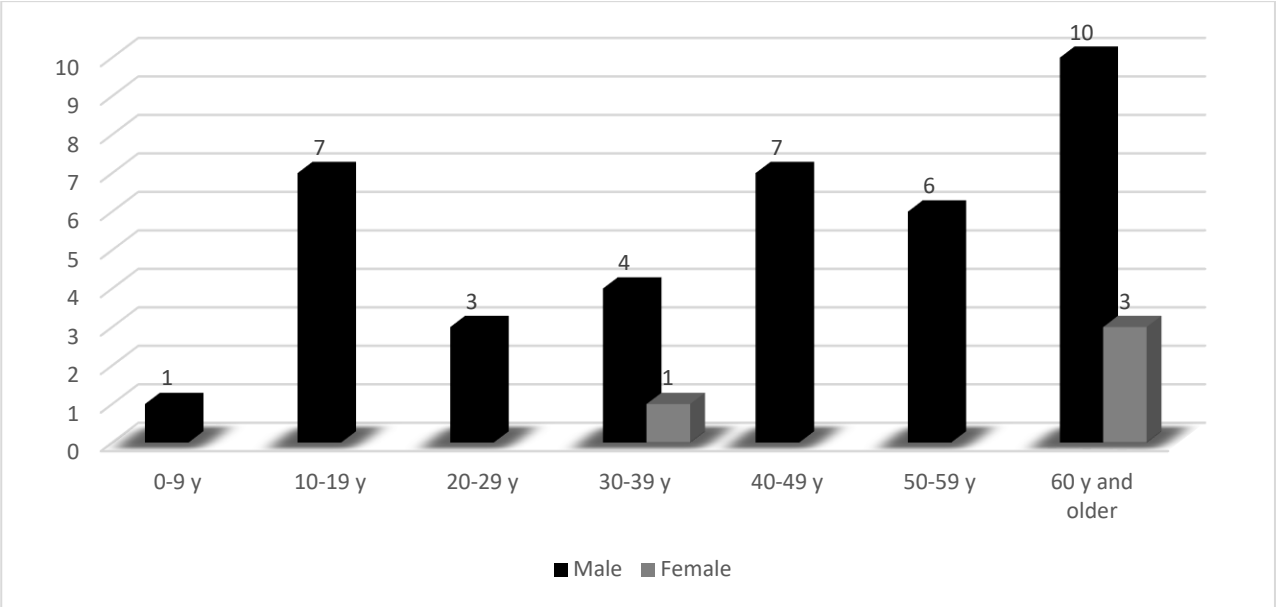

Figure 1: Age-gender distribution.

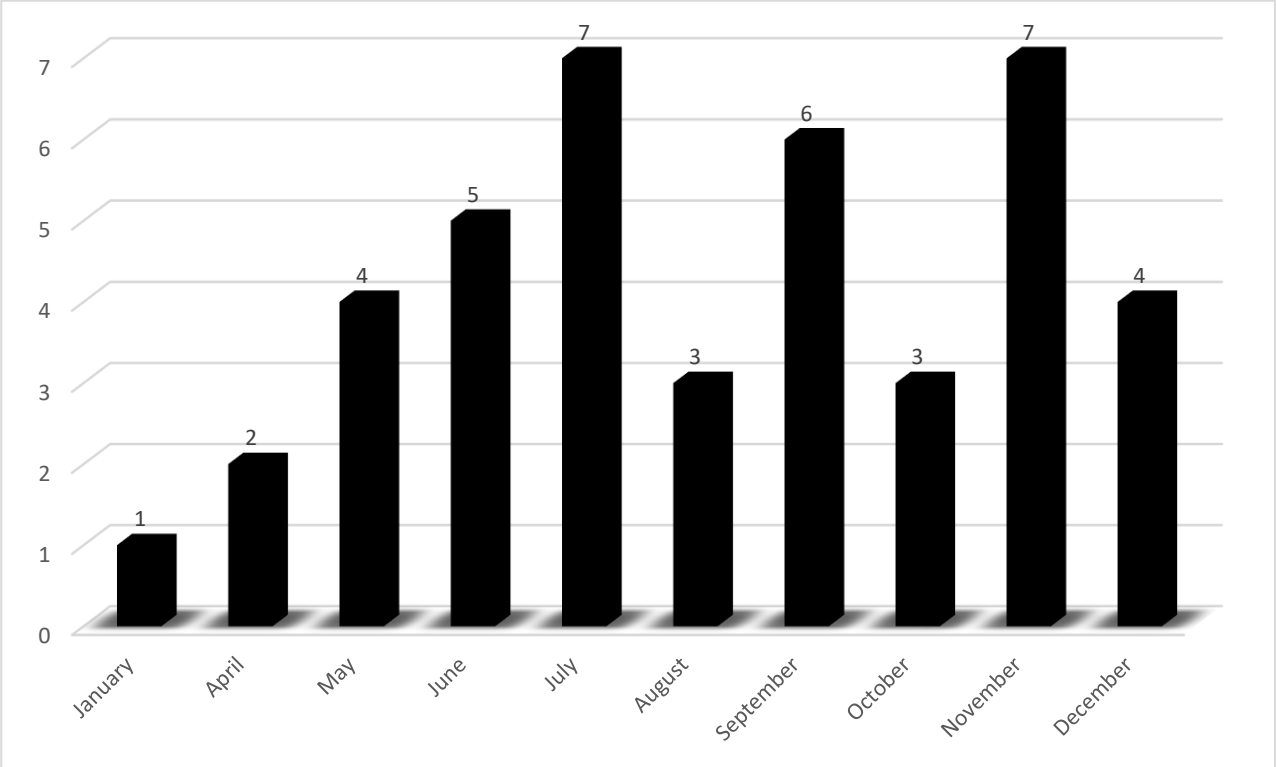

Figure 2: Distribution of the cases by months.

Of the 21 cases who died as a result of the tractor overturn, 20 were male (95.2%) and one was female (4.8%). The average age was 47.14±18.83 (min: 14, max: 80), and the most common age range was 60 years and over (n=7, 33.3%) (Table 1). All of the deceased cases (n=21) due to tractor overturn were drivers. The most common trauma was found to be chest trauma alone (n=5, 25%) and chest-neck trauma (n=5, 25%) (Table 2). The most common cause of death was mechanical asphyxia (n=9, 42.9%) due to chest and abdominal compression (Table 3).

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Table 1: Age group- event evaluation.

Age (Years)	Rollover		Fall		Traffic Accident		Crushing		Lightning Strike		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
0-9	-	-	1	2.4	-	-					1	2.4
10-19	3	7.1	2	4.8	-	-	1	2.4	1	2.4	7	16.7
20-29	-	-	-	-	3	7.1	-	-	-	-	3	7.1
30-39	4	9.5	1	2.4	-	-	-	-	-	-	5	11.9
40-49	6	-	1	2.4	-	-	-	-	-	-	7	16.7
50-59	1	2.4	3	7.1	-	-	1	2.4	1	2.4	6	14.3
≥60	7	16.7	5	11.9	-	-	1	2.4			13	31
Total	21	50	13	31	3	7.1	3	7.1	2	4.8	42	100

Table 2: Trauma site- event evaluation.

Trauma	Rollover		Fall		Traffic Accident		Crushing		Lightning Strike		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
Chest	5	11.9	6	14.3	-	-	-	-	2	4.8	13	31
Neck	1	2.4	2	4.8	-	-	-	-	-	-	3	7.1
Head	-	-	1	2.4	1	2.4	-	-	-	-	2	4.8
Abdomen	1	2.4	2	4.8	-	-	-	-	-	-	3	7.1
Chest-Neck	5	11.9	-	-	-	-	1	2.4	-	-	5	11.9
Chest-Head	-	-	-	-	1	2.4	1	2.4	-	-	2	4.8
Chest-Abdomen	3	7.1	-	-	1	2.4	1	2.4	-	-	5	11.9
Chest-Extremity	2	4.8	-	-	-	-	-	-	-	-	2	4.8
Chest-Neck-Head	1	2.4	-	-	-	-	-	-	-	-	1	2.4
Chest-Neck-Abdomen	1	2.4	-	-	-	-	-	-	-	-	1	2.4
Chest-Abdomen-Extremity	1	2.4	1	2.4	-	-	-	-	-	-	2	4.8
Neck-Head	1	2.4	1	2.4	-	-	-	-	-	-	2	4.8
Total	21	50	13	31	3	7.1	3	7.1	2	4.8	42	100

Of the 13 cases who died as a result of the falling from the tractor, 10 were male (76.9%) and three were female (23.1%). The average age was 43,69±24,08, and the most common age range was 60 years and over (n=5, 38,5%) (Table 1). All of the deceased cases (n=13) due to falling from the tractor were passengers. The most common trauma was found to be chest trauma alone (n=6, 46,2%) (Table 2). The most common cause of death was internal bleeding due to internal organ injury (Table 3).

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Table 3: Cause of death- event evaluation

Cause of death	Rollover		Fall		Traffic Accident		Crushing		Lightning Strike		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
Mechanical asphyxia	9	21.3	-	-	-	-	-	-	-	-	9	21.3
Internal organ injury	5	11.9	7	16.6	1	2.4	-	-	-	-	13	31
Celebral hemorrhage	-	-	1	2.4	1	2.4	1	2.4	-	-	3	7.2
Drowning	1	2.4	-	-	-	-	-	-	-	-	1	2.4
Medulla spinalis injury	1	2.4	2	4.8	-	-	-	-	-	-	3	7.2
Diffuse soft tissue bleeding	1	2.4	-	-	-	-	-	-	-	-	1	2.4
Large vessel injury	1	2.4	-	-	-	-	-	-	-	-	1	2.4
Lightning strike	-	-	-	-	-	-	-	-	2	4.8	2	4.8
Mechanical asphyxia-Medulla spinalis injury	1	2.4	-	-	-	-	-	-	-	-	1	2.4
Internal organ injury-Brain hemorrhage	-	-	-	-	1	2.4	-	-	-	-	1	2.4
Internal organ and large vessel injury	1	2.4	2	4.8	-	-	1	2.4	-	-	4	9.6
Celebral hemorrhage – Medulla spinalis injury	1	2.4	1	2.4	-	-	-	-	-	-	2	4.8
Large vessel injury-medulla spinalis injury	-	-	-	-	-	-	1	2.4	-	-	1	2.4
Total (%)	21	50	13	31	3	7.2	3	7.2	2	4.8	42	100

All of the three cases who died as a result of a tractor accident were male. The mean age was 26.66±2 (min: 25, max: 29) and, all of them were drivers in the 20-29 age range (Table 1).

All of the three cases who died as a result of running over were male pedestrians and the mean age was 44.33±27.31 (min: 14, max: 67). Two male18 and 56-year-old drivers were found to have died as a result of lightning strikes on the tractor while working in the field.

DISCUSSION

Tractors are responsible for a significant proportion of deaths related to agricultural practices (5). It is estimated that more than 800 people die every year by tractor accidents in the United States, with at least 40 injuries per person who died (6). Tractor accidents were the most common cause of agriculture-related injuries in India (27.7%) (7). Risk factors for death in tractor accidents were defined as follows: "not assessing operational risks (mechanical properties of the vehicle, uneven terrain etc); lack of safety equipment (roll-over protective

structures (ROPS), seat belt, helmet, etc); old tractors, poor maintenance, low tire pressure; intense farm work or physical activity for long hours of day and night in unfavorable weather conditions; working alone in isolated locations where is difficult to alert emergency rescuers, delayed hospital transport and medical intervention" (2).

As tractors designed to reduce the labor force in agriculture are often used on risky roads such as inclined lands, tractor mechanisms called ROPS have to be developed to prevent roll-over protection (8). On the other hand, most of the old tractors do not have protective equipment and in new tractors, protective equipment may be removed by users (8,9).

The majority of tractor-related deaths were male (10-14). The vast majority (89.5%) of deaths due to tractor accidents in Portugal were male (8). In Turkey, 66.6-92.86% of deaths due to tractor accidents were male (3,11,12,14). In this study, most of the tractor-related deaths were male (n=38, 90.5%) in accordance with the literature.

More than half of the victims who died as a result of tractor accidents in Portugal were over 60 years old (56.1%) (8). Rondelli et al. (9) reported that 42.2% of fatal tractor accidents were over the age of 65. Karbeyaz et al. (12) reported that the average age in deaths due to tractor accidents was 48.7±27.5 and 27.9% of cases were 65 years and older in Eskişehir. Erkol et al. (14) determined the average age of tractors-related deaths was 42.5±25.1 years, and 34.1% of cases were over 60 years of age. In this study, the average age of cases was 44.54±20.66, and the death was most common in people 60 years and older (n=13, 31%). In older farmers engaged in agriculture, tractor accident related death probability is higher as a result of often working alone in the field with isolated conditions, being more susceptible to trauma due to age-related fundamental wellbeing issues, and decreased ability to escape traumatic injury due to decreasing reflex (15).

Erkol et al. (14) reported that tractor-related deaths occurred most frequently in June (19.5%) and July (17.1%). Tractor-related deaths occurred most frequently in July (17.4%) and August (16.3%) in Konya (11). In Eskişehir and Elâzığ tractor-related deaths were most common in summer and autumn (12,16). In this study, tractor-related deaths occurred most frequently in July and November (n=7, 16.6%), and 73.8% (n=31) of deaths occurred in summer and autumn.

In Eskisehir, 52.6% of the victims of tractor accidents were drivers, 32.7% were passengers and 14.7% were pedestrians (12). In Konya, passengers were victims (43%) for the majority of tractor-related deaths, while drivers (39.5%) were the second (11). More than half of the tractor-related deaths (57.1%) in Elazig were drivers (16). In the study of Erkol et al. (14), the victims were most frequently passengers (39%) in tractor-related deaths, followed by drivers (34.1%). In the current study, it was determined more than half of the cases were drivers (61.9%), 30.9% were passengers and 7.2% were pedestrians.

In a study involving 513 non-lethal tractor injuries, rollover (25%) was the most common mechanism, and falling was the second most common mechanism of injury (20%) (17). The most common cause of tractor-related deaths between 1985 and 2010 in Australia was tractor overturning (42%), followed by crushing accidents (29%) (18). Rollover was in charge of over half (54%) of tractor-related deaths in the 11-year period in Virginia (10). Similarly, in a 10-year study in Portugal, tractor-related deaths occurred most frequently due to overturning (38.6%) and subsequent falling (19.3%) (8). Erkol et al. (14) reported that deaths due to tractors occurred as a result of overturning in 34.1%. In Eskişehir, the reason for deaths due to tractor accidents were overturning in 45.9% and crushing in 21.3% (12). In the study of Turkoglu et al. (16), the most common cause of tractor-related deaths was reported as overturning. Dogan et al. (11) reported overturning was

responsible for 37.2% of deaths due to tractors. 50% of the deaths in this study were caused by tractor overturning and 31% by falling from the tractor.

Thoracic trauma and spinal injuries are claimed to be significantly higher in tractor accidents (19). Injuries due to the head, chest, and abdominal trauma were the main causes of tractor-related deaths in Portugal (8). Chest and abdominal trauma (%22) was the most common reason for tractor-related deaths in the study of Erkol et al. (14). However, deaths due to tractor accidents in Konya and Eskişehir were most frequently associated with head trauma (33.7% and 29.5%, respectively) (11,12). In this study, 32 cases (76.2%) had chest trauma and isolated chest trauma (n=13, 31%) was the most frequent cause of death.

Overturning of tractors is significantly associated with high severity injury (17). Therefore, protective structures called ROPS have been developed to prevent tractor overturns (9,20-22). ROPS limits tractor rollover to 90 °, thus reducing injury severity associated with continuous rollers (22). Tractors equipped with ROPS reduce both mortality and hospitalization time (23). In a survey study involving 535 tractor overturns (92 equipped with ROPS (17%), 443 non-ROPS (83%)), in tractors with and without ROPS; side rollover rate was reported to be 67% and 54%, respectively, and the mortality rate in the side rollover, was reported to be 1.6% and 3.7%, respectively. In the same study, 13% of ROPS-equipped tractor overturns were non-fatal injuries with an average of one-day hospitalization, however, 39% of tractor rollovers without ROPS were non-fatal injuries and an average of 13 days were hospitalization was stated (22). Özdeş et al. (3) reported that deaths due to tractor overturn were most common in the age range of 50-59 (21.42%), however, 23.8% of cases were 60 years old or older. In Rondellli et al studies, it was shown that 42.2% of fatal tractor overturns were over 65 years old and 78.2% of them used tractors without ROPS in the overturning event (9). Advanced age was a significant determinant of severe injury in tractor accidents (17). In this study, the average age of 21 patients who died due to tractor overturns was 47.14±18.83, and 33.33% were over 60 years old. Özdeş et al. (3) reported that the most common cause of death associated with tractor accidents was chest trauma (57.14%). On the other hand, Karbeyaz et al. (12) stated that head and head-chest trauma were seen most frequently in tractor overturning. The most frequent fatal trauma as a result of the overturning of our cases occurred in the chest and chest-neck regions alone (n=5, 23.8%). Erkol et al. (14) reported that 64.3% of those who died as a result of the overturn of the tractor were drivers, while Özdeş et al. (3) reported that 80.96% were drivers. All cases in this study were drivers. Tractor overturning may cause serious visceral injuries, as well as mechanical asphyxia due to neck-chest-abdominal compression (2). In such injuries, swelling and intense purple congestion of the face and neck, petechial hemorrhages on all face, and conjunctivas may be observed (24). In addition, these characteristic pathological findings may not be seen in approximately 5% of mechanical asphyxia due to vehicles (25). In this study, no internal organ injury was detected in 42.85% (n=9) of the cases who died as a result of tractor overturning, and death was attributed to mechanical asphyxia according to the characteristic pathological findings in autopsy. The task of forensic physicians in a tractor injury that develops with this mechanism is to determine whether this is a real accident and whether the mechanical parts of the vehicle are compatible with existing traumatic lesions that cause asphyxia (2).

In a study involving 513 non-lethal tractor injuries, falling was the second most common injury mechanism (20%) but it was associated with less severe injury (17). The second most common cause of tractor-related deaths in Portugal was fall-related injuries (19.3%) (8). Deaths as a result of falling from a tractor were responsible for 14.8-22% of tractor-related deaths in Turkey (11,12,14). In this study, falling from a tractor (31%) was the second most common cause of death

among tractor-related deaths. In addition, five (38%) of the cases were 60 years old and above, and all of the cases were passengers. Doğan et al. (11) argued the opinion that being a passenger is the most important risk factor for tractor-related deaths. Likewise, Karbeyaz et al. reported that falling from the tractor was the most common cause of passenger deaths (12). Tractors are not suitable for passenger transport as they are designed as agricultural vehicles (16). Unfortunately, nowadays, tractors may frequently be used in passenger transportation, especially in rural areas. For this reason, it is necessary to raise the awareness of tractor users that the tractor is unsafe in carrying passengers and to increase the inspections for tractors carrying passengers.

Drivers involved in tractor-related traffic accidents in Sweden were mostly young drivers (15-24 years old), and collisions with automobiles (58%) were the most common (26). Young drivers have been identified as a risk factor for traffic accidents with agricultural equipment (27). In this study, all of the drivers involved in a traffic accident were in the 20-29 age group. This may be due to the desire for fast driving, although young drivers involved in a traffic accident do not have enough experience.

Two male drivers aged 18 and 56 were found to have died as a result of lightning strikes on the tractor while working in the field in May and June, respectively. Lightning may damage the person with direct effect, as well as with indirect effect that is to say by hitting an object that the victim touches (28). A tractor operating in an open area can pose a risk of lightning strikes, and new generation tractors, such as cars with many electronic components, can also be the target of lightning (28). Two cases who died due to lightning strikes were determined to be exposed to this attack while working with a tractor in the open terrain. In a study on automobiles, it was shown that the most likely target of lightning is antennas, and then the front hood and windshield are targeted (28). Lightning strikes are more common during hot seasons in which outdoor activity increases (29). In this study, both cases were found to expose to lightning strikes between May and June. Tractors operating on open fields, including new tractors with increased electronic components, may be a risk factor for lightning strikes, but we currently do not have sufficient data. However, it may be beneficial to add lightning arrester structures to tractors to prevent such deaths.

Our study has some limitations. A limitation of the study is that it was prepared retrospectively. Another limitation is the lack of data on tractors' age, mechanical properties, and whether they have ROPS.

In this study, half of the deaths were due to overturning. The average age of tractors was 22-23 in Turkey. The Turkish Agricultural Tools and Machinery Manufacturers Association reported that in 2016 there were 816,547 tractors over 25 years old and 50.9% of them were 40 years old and over. Especially older tractors often lack protection mechanisms such as seat belts or ROPS, and this situation often results in death and serious injuries (26). Rondelli et al. (9) reported that non-ROPS tractors are responsible for 71.7% of fatal accidents and interestingly, in 26.5% of these non-ROPS tractors in which ROPS are folded or taken out. This situation shows that farmers do not have enough information about the benefits of ROPS equipment and necessary training should be given in this regard. In addition, in the survey study of Myers et al, 18 of the 19 operators wearing seat belts in the overturning of ROPS-equipped tractors had no injuries, while only one received outpatient treatment. They claimed that although the seat belt is known to save lives, the ROPS is safer than the seat belt, the seat belt is a secondary safety device for ROPS (21). In the study of Antunes et al, they concluded that although there are protective structures on the tractor in some deaths due to tractor accidents, protective structures did not provide any protective benefits due to lowered down or not being placed correctly (8). We suggest that giving education to tractor operators about "the correct use of ROPS, seat

belts and not to be used in passenger transport" may contribute to the reduction of tractor accidents and rollover that can result in death.

We found that 31% of tractor-related deaths were associated with age 60 and over. Old age adults' reflexes decrease, visual disturbances increase, the level of alertness decreases and they become vulnerable to trauma. Accordingly, we suggest that tailor-made training programs for tractor operators over the age of 60 should be opened, and they should be subjected to go through medical examinations regularly every year for the maintenance of their driving license.

Conflict of Interest: There is no conflict of interest between the authors in this study. All authors have participated in (a) conception and design, or analysis and interpretation of the data; (b) drafting the article or revising it critically for important intellectual content; and (c) approval of the final version.

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Ethics Committe Aproval: Bolu Abant Izzet Baysal University Clinical Research Ethics Committee, date:19.10.2020, issue number: 427.

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