Antilock Breaking System Effectiveness in Prevention of Road Traffic Crashes in Iran

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Abstract

Background*:* Anti-lock Brake System (ABS) helps the equipped vehicles to stop under heavy braking, in a shorter distance and with a better control of direction. It was expected that this technology will reduce the rate of fatal road traffic crashes (RTC); however, the outcome was controversial in the real world.

Aim: The aim of this study was to compare the claimed annual incidence and financial loss due to RTC in ABS vs. non-ABS personal vehicles in Iran.

Methods: A telephone survey among drivers of two similar models of personal vehicles was arranged. The studied models were of the same brand and type; but only one of them was equipped with ABS. The number of RTCs, subsequent financial loss, and drivers' knowledge and perception about ABS were sought. The sample consisted of drivers of 1232 ABS and 3123 non-ABS vehicles.

Results: The mean financial loss due to reported RTCs was $987.9 ±$1547.3 US Dollars. They were similar in both study groups. The incidence of RTC with another vehicle due to brake failure, was 50.3 (42.9-58.5) for 1000 non ABS vehicle-years and 30.0 (21.2-41.2) for 1000 ABS equipped vehicle-years. The difference was statistically significant after adjustment for the driver and vehicle's age and the daily driving time. The attributable risk of RTC for non-ABS vehicles was 20/1000 vehicles and the excess fraction was 39.8%. While 61.1% of ABS vehicle drivers reported situations in which they believed the ABS had prevented a crash, 44.1% of them did not know how to use ABS efficiently.

Conclusions: Safety authorities in Iran and similar Middle Eastern countries should first invest to prepare a list of priorities, considering the global experience and local evidence, before adopting any specific policy in this regard. The drivers need to learn the right way to use ABS for maximum effectiveness.

Background

Being a major public health and development problem worldwide, road traffic injuries (RTIs) are increasing in upcoming years (1). RTI puts a psychological and financial impacts on family and survivors as well (2). Some jurisdictions are going to consider the mandatory introduction of Electronic stability control (ESC) systems, including Anti-lock Brake System (ABS), as an effort to reduce Road Traffic Crashes (RTCs) (3-4).

ABS helps the equipped vehicles to stop under heavy braking, in a shorter distance, and with a much better control of direction than the conventional brake systems. In motor vehicles with conventional brake system, during a heavy braking or whenever the wheels begin to lock (such as seasonal iced or wet pavement), the force of the brake stopping the wheels exceed the force making them rotate. Hence, such interference leads to skidding of the wheels which in turn, not only brings loss of directional control, but produces a very long stopping line in the pathway. However, the antilock brake system confronts the consistent force by reducing the pressure of liquid supplying the brake, so the brake force will increase just enough to a maximum level which is proper for stopping the car and in part not that much to lead to wheels lockup (5-6). It was expected that this technology will reduce the rate of RTC and then the RTIs or obstacle avoidance, as was seen in track tests (5-6). However, the story was controversial in the real world (7-12).

Iran with a population of 74 million and about 23000 fatal RTIs annually, experiences a high rate of RTI (2, 13-14). Only a small fraction of vehicles are equipped with ABS in Iran and the world (2-3, 14). The mandatory outfitting of new cars is under debate, considering the controversy mentioned above and the concerns about technical proficiency of local car manufacturers to provide effective and standard ABS for all new cars. The aim of this study was to compare the claimed annual incidence of RTC in ABS equipped vs. conventional brake systems personal cars in Iran to provide a preliminary evidence for this debate.

Materials and Methods

This study was conducted in Iran with a landmass of 1.648.000 km^2 and the population density of about 45 inhabitants /km^2. The total number of registered vehicles was about 14 million and the number of vehicles per 1000 inhabitants was equal to 13.

The study design was historical cohort. The study population was the drivers of two similar vehicles of the same brand and the same engine, while the main difference between them was the ABS installation. The unexposed groups' vehicles were equipped with ABS while the exposed group had the traditional brake system. Study period was March 2007 to March 2008 (one complete Persian calendar year). We called the study subjects at the end of the Persian year and asked them to report their age (years), sex, the frequency of intercity trips, the number of people who drove the vehicle and the vehicle's age. They were asked to report the mean daily driving time (DDT) in hours and their answers were verified according to the frequency of gas fillings. The number of traffic collisions during the past Persian calendar period and the information on the reported collisions including the cause, financial toll, injuries and the role of brake failure (according to their perception) was sought. Accordingly, crashes due to brake failure were defined as "crashes that could potentially be avoided if the brakes stopped the cars faster or if cars did not skid while braking". To explore the knowledge of drivers about the right way to use ABS, the unexposed group was asked to report how they usually used the (ABS) brake.

Case selection

The sample consisted of drivers of 1232 ABS equipped, and 3123 conventional brake system car drivers that were identified according to the registry of the Central Insurance Organization. The inclusion criterion was as follows: being a driver of the selected car during the study period. Those informants who were not the main driver of the studied vehicle and those who declined to participate in the study were excluded.

Data treatment

The mean and standard deviation (SD) was calculated for continuous data; and student's t test was used for comparing continuous variables. The relative frequency of categorical variables was calculated as percentage; and Chi-square test was used for between groups comparison. The incidences are reported as point estimate and 95% confidence interval; the Poisson distribution

assumption was used to calculate the confidence interval. P-value < 0.05 was considered as statistically significant.

Poisson regression analysis was utilized to compare the number of RTCs due to brake failure among ABS vs. conventional vehicles, controlling for the effect of other variables. The STATA version 8.00 SE was used for data analysis. The study was approved by Sina Trauma Research Center affiliated to Tehran University of Medical Sciences.

Results

In total, 795 (18.2%) of responders were female, with a male-to-female ratio of 4.9/1. The mean age of drivers was 40.3±10.3 years and the mean daily drive time (DDT) was 2.1±1.9 hours. The mean age of cars equipped with ABS was 3.7±1.5 and cars without ABS was 4.1±1.8 years (P<0.001) (figure1). Among all reported crashes, 75% had occurred in urban areas.

In 2323 (53.1%) cases, the cars were exclusively driven by the responding driver; however, in 1849 (42.3%) cases, the cars were reported to be driven by another driver as well. The remainder 4.6% of the studied vehicles had more than three drivers. Among ABS vehicle drivers, 61.1% reported situations in which they believed ABS had prevented a crash. On the other hand, 44.1% of ABS vehicle drivers did not know the right way to use ABS.

The incidence of all, injurious and fatal traffic crashes were 145.1 (134.8-155.9), 9.6 (7.0-13.0), and 0.5 (0.1-1.7) per 1000 vehicles (of studied type), respectively. The relative frequency of reported injuries due to RTC were as follows: bone fracture (42.3%), superficial (23.1%), contusion (15.4%), head injury (11.5%), amputation (3.8%), and internal bleeding (3.8%).

The mean financial loss due to reported RTCs was $987.9 ±$1547.3 United States (US) dollars (Median: $538.6; Range: $21.5-$26930.9). The average exchange rate during the study period was US$ 1.00 = 9283 Iranian Rials (15). There was not a statistically significant difference among study groups.

All Crashes

The overall annual incidence of RTC involving another vehicle was 145.1 (134.8-155.9) per 1000 vehicle-years. There was not a statistically significant difference in the reported incidence

of RTC in ABS vs. conventional brake system vehicles (P=0.39). Moreover, the difference failed to attain statistical significance in Poisson regression analysis after adjustment for the effects of age of driver, age of vehicle, number of drivers, DDT and the frequency of inter-city trips.

The incidence of death and injury per 1000 RTC were 12.6 (1.5-45.4) and 69.2 (34.5-123.8) for conventional brake systems vehicles; and 0 (0-97.0) and 26.3 (0.6-146.6) for ABS equipped vehicles, respectively. The difference was not statistically significant (table 1).

The incidence of hitting a pedestrian by a car was 5.3 (3.4-7.9) per 1000 vehicles and there was not a statistically significant difference between ABS vs. conventional brake system vehicles.

The power of study to detect a 10%, 20% and 30% difference in the incidence of RTCs in the ABS compared to non-ABS vehicles was 0.20, 0.65, and 0.96 respectively.

Crashes due to brake failure

The incidence of RTC due to brake failure with another vehicle was 50.3 (42.9-58.5) for 1000 conventional brake system vehicle-years vs. 30.3 (21.2-41.2) for 1000 ABS equipped vehicle-years (P<0.01). The attributable risk of RTC for conventional brake systems vehicles compared to ABS vehicles was 20.0 (7.7-32.3) per 1000 vehicles, and the excess fraction was 39.8% (14.4%-57.7%).Table 2 represents the association of ABS with the number of RTC due to brake failure, controlling the effect of other variables, using Poisson regression model.

To non-ABS vehicles was 0.20, 0.65, and 0.96 respectively.

Discussion

This study is the first one in the region, to our knowledge, that gauges the effectiveness of the ABS in practice and in the Middle Eastern climate. The annual incidence of RTC in this study was similar to population based estimates in Iran (16); therefore, the sample included in this study could be considered a representative sample of Iranian drivers. Drivers of ABS equipped vehicles reported less RTCs due to brake failure compared to similar vehicles that were not

equipped with ABS. However, there was not a difference in the annual incidence of total, injurious and fatal RTCs between the two groups. A 39.8% excess fraction for RTCs due to brake failure in non-ABS vehicles indicates usefulness of ABS to prevent traffic collisions. However, lack of support for the difference by objective outcome measures such as actual RTCs, raise a question on effectiveness of ABS in Iran. On the other hand, poor knowledge of drivers of ABS equipped vehicles about the right way to use ABS may invalidate their judgment about the effectiveness of ABS in preventing RTCs due to brake failure.

The power of this study indicates that it is highly unlikely that ABS had decreased the rate of RTCs to 30%. However, it is quite possible that ABS has been effective in preventing RTCs but it has been less than the extent that could be detected by this study.

It has been expected that ABS technology will reduce the rate of road traffic crash and RTIs, ,as was seen in track tests (5-6). However, the story has been controversial in the real world (7-12). The Highway Loss Data Institute (HLDI) has shown that no change in claim frequency had been observed after adding this technology (17). The incidence of single-vehicle crashes in ABS equipped cars was reported high while it had been diminished in multiple-vehicle setting (18-19).

There are reports indicating decreased road traffic injuries and increased fatal RTCs by ABS installation (10-11, 19-20). Moreover, a significant increase in overturning crash, single-vehicle crash and collisions with fixed objects has been attributed to ABS installation (7, 21-22). While Evans and Gerrish proposed the risk compensation as an explanation (21), Kahane claimed improper operation of ABS equipped vehicles as the reason for failure of this technique to prevent all forms of RTC (11), which got its support by Harless study in 2002 (22). Improper usage of ABS may be another reason that prevents ABS to appear as effective as expected. A noticeable fraction of drivers of ABS equipped vehicles in our study either released the brake pedal when they felt “a sense of crashing under their feet”, or pumped the pedal in a same way as they did in conventional brakes. This is in line with a study conducted in North Carolina and Wisconsin which showed that close to half of drivers did not have the knowledge of ABS use (19). This is more attentive when a positive effect has been seen after training the drivers to use ABS by the transfer of verbal knowledge [3]. However, at this time, there is no training for drivers whose vehicles are equipped with ABS in Iran. It seems necessary to provide

comprehensible information about how to use ABS for optimal performance and how ABS could improve the safety while braking.

Car manufacturers in Iran have been recently ought to install ABS for all their products. However, there are concerns about proper operation of ABS when outfitted into cars for which they were not originally designed for. While mandatory outfitting of all cars with ABS can improve safety, it is noteworthy to consider the cost effectiveness of this policy. The benefit to cost ratio of ABS installation of vehicle has been reported as 0.7 in Norway (23). This ratio has been reported as 1.3 for child restraints, 3.3 for mandatory daytime running lights for cars, 16.7 for vehicle crashworthiness in cars by using collapsible steering columns, and 31.7 for safety seat belts of drivers. Safety authorities in Iran and similar Middle Eastern countries should first invest to prepare a list of priorities, considering the global experience and local evidence, before adopting any specific policy in this regard. This study could be considered as local evidence; however, it needs to be repeated with additional sample size in different settings, i.e. diverse climates and types of vehicles.

Limitation and strength of study

This study asked the drivers to report their car crashes due to brake failure. Drivers of non-ABS vehicles might believe that "if their car had been equipped with ABS, then it would not have crashed, and therefore overestimate "the crashes due to brake failure". On the other hand, drivers of ABS equipped vehicles may expect a lot from the ABS; therefore, overestimating "the crashes due to brake failure". Therefore, the overestimation in one group may have been compensated in the other group; however we were not able to measure it.

Conclusions

While ABS was believed to have prevent RTCs that were due to brake failure up to 40%, its cost-effectiveness needs to be evaluated in different settings with different type of vehicles. Safety authorities in Iran and similar Middle Eastern countries should first invest to prepare a list of priorities, considering the global experience and local evidence, before adopting any specific

policy in this regard. The drivers need to learn the right way to use ABS for maximum effectiveness.

List of Abbreviations

ABS: Antilock Braking System

RTI: Road Traffic Injury

HLDI: Highway Loss Data Institute

DDT: Daily Drive Time

Electronic stability control (ESC)

RTC: Road Traffic Crashes

Competing interest

There is no conflict of interest in any forms which could affect this study.

Authors' Contribution

Soheil Saadat has designed the study, participated in data analysis and interpretation, and preparation of the manuscript. Davoud Khorasani Zavareh has participated in drafting the manuscript. Saeed Shoar has also participated in drafting the manuscript and literature review.

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Table1. Comparison of injurious and fatal RTCs in vehicles equipped with ABS vs. Non ABS vehicles

		ABS		P value
		Yes N (%)	No N (%)	
Injury	Yes	1 (2.6)	11 (6.9)	0.32
	No	37 (97.4)	148 (93.1)	
Death	Yes	0 (0.0)	2 (1.3)	0.49
	No	38 (100.0)	157 (98.7)	

Table2. Association of ABS with RTCs due to brake failure, controlling the effect of potential confounders

Variable	Coefficient	SD	z	P value
ABS	-0.55	0.19	-2.90	0.004
Driver's age (years)	-0.02	0.01	-3.01	0.003
DDT (hours)	0.10	0.03	3.63	0.000
Car age (years)	-0.09	0.04	-2.01	0.045
Model constant	-1.96	0.36	-5.44	0.000

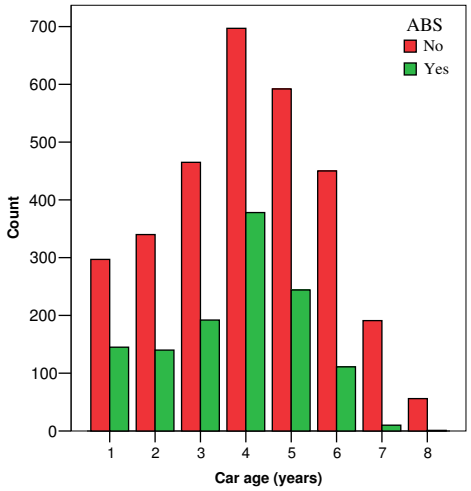

Figure1. The mean age of ABS versus non-ABS vehicles in the study

Figure 1

Additional files provided with this submission:

Additional file 1: Cover Letter.doc, 26K
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