ARE AIRBAGS AND CHILD RESTRAINTS LETHAL COMBINATIONS?

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INTRODUCTION

In NSW it is currently illegal for a child in a child restraint to travel in the front seat of a vehicle equipped with an active airbag for that position. This restriction has been informed by caution in Australia and adverse experiences in the USA, where some restrained and unrestrained children have been killed in these positions in airbag-equipped cars. Even though the protective benefit of airbags in combination with adult seatbelts is recognised, there is a concern that the proximity of a child and/or restraint to the airbag, coupled with a child's vulnerability, may lead to situations where a child is injured by the inflating airbag.

Some vehicles, such as utilities and sports cars, have either no rear seat or the rear seat is too small for standard child restraints. In recent years some vehicle manufacturers are producing a single cab utility that is equipped with a passenger airbag and child restraint anchorage points. The Airbag Child Restraint Interaction Program (ACRIP) project was initiated by the RTA to investigate this road safety issue.

METHODOLOGY

This study used simulated frontal and oblique impacts and resultant biomechanical data to investigate the injury risks associated with children in a position protected by an airbag and compared the injury risks between children restrained in child restraints in front seats (with and without airbags) and those in rear seats. The test methodology for dynamic testing is based on Australian/New Zealand Standard 1754:2000 "Child restraint systems for use in motor vehicles" [1]. This involves an occupied child restraint installed on a test seat, which is mounted on a dynamic crash sled that produces the required impact conditions, to determine the suitability for use of the child restraint. The ACRIP diverged from that level of sled testing, by utilising an actual vehicle body to determine the interaction between a child restraint and vehicle airbag. A typical frontal test set up is presented in Figure 1.

To provide a comparison for evaluation, the program incorporated airbag and non airbag deployment, including an 'out of phase' and a 'stationary' airbag test. The tests also included the dummies being restrained by the vehicle seat belt only and within an installed child restraint. A new Ford Falcon BA utility body (test buck) was used and modified to meet the requirements of the ACRIP.

Five P series child dummies were used in the study, i.e. P-10, P-6, P-3, P-11/2 and P-3/4. These dummies were instrumented to measure head and chest responses. In addition, P-3/4 dummy was instrumented to measure neck response. The following child restraint systems (CRSs) were used in the study in addition to seatbelt only tests:

- A standard booster seat and booster cushion/ Type E CRSs
- Standard Forward Facing CRSs / Type B
- Standard Rearward Facing CRSs / Type A1 and A2

The front passenger seat was located in the fully forward or fully rearward position as the test program required. An exception was made for testing type A child restraints, where the installed device contacted the dash pad before the passenger seat could be positioned fully forward. The seat was then adjusted to the 'part forward' position, providing a space of approximately 25 mm between the child restraint and the dash pad. The test matrix is shown in Table 1. The complete test matrix is presented in the Crashlab's report [2].

Table 1. Test matrix and number of tests

Independent Variable	Frontal	45°
Dummy	5	5
CRS	9	5
Seat position – forward/rearward	2	2
Airbag deployment	2	2
Interaction between all variables (46)		

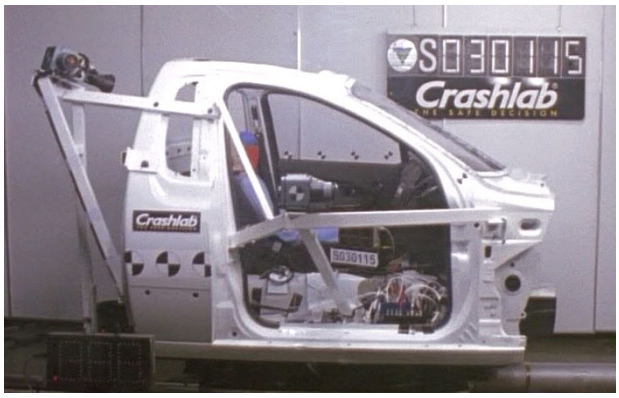

Figure 1. A typical frontal test set up.

In addition to the ACRIP data a series of ANCAP 64 km/h off-set frontal collisions was analysed. A P-11/2 and P-3 were in forward facing child restraints in the rear of the following five vehicles: Daewoo Kalo, Mitsubishi Magna, Honda Jazz, Holden Cruze, and Hyundai Getz. The assumption with this comparison is that real world results indicate that in these crashes there is a low likelihood that a child restrained in the rear would be injured; in fact, it could be argued that there is an 'acceptable' injury risk. Therefore, if the ACRIP dummy responses were lower than the ANCAP results, the same 'acceptability' might be applied to the consideration of the ACRIP objectives.

RESULTS AND DISCUSSION

A total of 78 tests were performed. Head and chest accelerations were measured in 76 tests. In one test the sled was motionless. Neck loads were measured on the P-3/4 dummy and belt loads were measured in about one half of the tests. Therefore, statistical analyses were conducted with a set of 75 sled tests with at least complete head and chest acceleration data. There were a total of thirty 45° impacts and forty-five frontal impacts in the sub-set of 75.

Non peer-reviewed extended abstract

A set of Injury Assessment Rating Values (IARVs) has been adopted for this study in the form of an ordinal scale. For example, IARV for Head Injury Criterion (HIC) under 600 is considered as low risk, 600-800 as moderate, and above 800 as high.

As an illustrative example on how airbag interacts with a child in a child restraint, Figures 2 and 3 demonstrate cases where a P-3 dummy was placed in a forward facing restraint and tested with and without airbag deployment at forward position of the seat. The maximum resultant of head acceleration and HIC values for airbag and non-airbag deployment tests were 72.6 g and 561 compared to 99.8 g and 858, respectively. It is clear, in this particular test, that the presence of the airbag helps reduce the risk of injuries, even when the seat was positioned at the fully forward position.

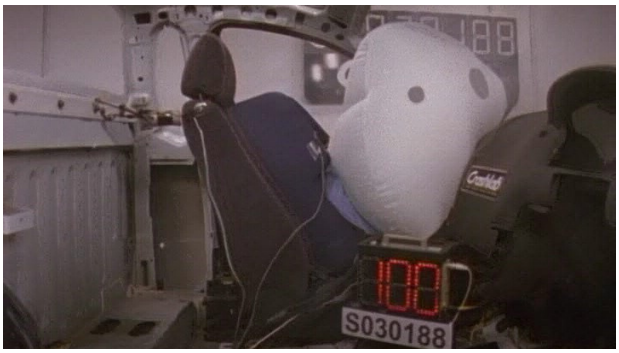

Figure 2. P-3 dummy in a forward facing CRS with airbag deployment

Figure 3. P-3 dummy in a forward facing CRS with no airbag deployment

Tables 2 and 3 present the descriptive statistics by airbag deployment. As shown that differences are fairly small in absolute terms. For example, the mean and maximum head accelerations and HIC values for airbag and non-airbag tests were 74 g, 211 g, 454 and 1277 compared with 82 g, 211 g, 533 and 1356, respectively.

Table 2. Descriptive statistics for results with airbag deployment

Airbag Deployed	Mean	Max.	Min.	SD
Max. Head Res. Acc. (g)	74	211	30	34
HIC (36)	454	1277	75	313
Max Chest Acc (g)	54	86	28	12
Chest HIC	297	876	99	150
Neck Fx (kN)	-0.11	-0.02	-0.4	0.11
Neck Fz (kN)	-0.31	-0.01	-1.37	0.38
Neck My (Nm)	-12.3	-1.50	-34.1	10.45

Table 3. Descriptive statistics for results with no airbag deployment

Airbag Not Deployed	Mean	Max.	Min.	SD
Max. Head Res. Acc. (g)	82	211	35	48
HIC (36)	533	1356	82	394
Max Chest Acc (g)	60	87	33	15
Chest HIC	345	688	82	168
Neck Fx (kN)	-0.07	-0.01	-0.12	0.04
Neck Fz (kN)	-0.21	0.0	-0.53	0.21
Neck My (Nm)	-20.9	-7.4	-37.2	12.78

The ANCAP test results for the five vehicles mentioned earlier are presented in Table 4. For the P-3 dummy, both mean and maximum results are generally greater than those observed in the ACRIP study. The head accelerations measured on the P-11/2 are similar in both studies, but with higher HIC values in the ANCAP series. Chest accelerations are comparable for the P-11/2 in both test series as well as the P-3 dummies.

Table 4. ANCAP P-3 and P-11/2 results [3]

	Res. Head Acc (g)	HIC 36	Chest Ax (g)	Chest Ay (g)	Chest Az (g)
	P11/2				
Mean	78	1070	35	23	24
SD	13	363	8	5	6
Max	97	1679	47	27	33
Min	62	720	27	15	16
	P3				
Mean	93	1078	42	16	43
SD	19	235	7	5	14
Max	120	1441	53	22	68
Min	68	828	34	8	33

CONCLUSIONS

The results suggest that a front passenger airbag has the potential to significantly reduce injury risks, and at worst makes no difference, to a child correctly and appropriately restrained in a forward-facing restraint or booster seat. This could be attributed to Australian airbags being designed as supplementary restraint systems to the lap-sash seatbelt. As a result, the airbags fire later and inflate with less force. A similar result was observed for a child in a rearward-facing restraint, however, further investigation is required to analyse cases where the restraint is abutted against the dash-mounted-airbag unit. The study also suggests that when the ACRIP and ANCAP data are compared, it indicates that a child in an age appropriate restraint in the front seat is not at a higher risk of injury due to interaction with the airbag, than a child in the rear seat.

REFERENCES

1. Australian/ New Zealand Standard, 'Child Restraint Systems for Use in Motor vehicles: AS/NZS 1754:2000', 2001
2. RTA Crashlab, 'Airbag and Child Restraint Interaction Program. Special Report: SR 2003/091', 2003
3. A McIntosh, 'Report on the Airbag Child Restraint Interaction Program: Analysis and Review', Report prepared for the RTA, 2004