EFFECTS OF GLOSSOPHARYNGEAL INSUFFLATION ON CARDIAC FUNCTION:
An Echocardiographic Study in Elite Breath-hold Divers

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Background

- Breath-hold divers use a variety of techniques to increase lung volume beyond TLC to augment oxygen stores, increase intrathoracic gas for better pressure equalization and reduce chest compression allowing for free diving to greater depths.
- One technique used is glossopharyngeal insufflation also known as buccal pumping or lung packing.

Background

After maximal inspiration to TLC, the diver fills the mouth with air while the glottis remains closed, then opens the glottis and forces this air into the lung.

This results in an significant increase in lung volume above TLC and an increase in transpulmonary pressure.

Glossopharyngeal insufflation is associated with:

- decreased arterial blood pressure
- Increased heart rate
- decreased intrathoracic blood volume
- decreased cardiac size
- fall in stroke volume and LV performance
- light-headedness and even loss of consciousness

METHODS

- To study the cardiac effects of GI, we performed transthoracic echocardiography using the subcostal window in 5 elite breath-hold divers.
- Blood pressure, heart rate and echocardiograms were obtained at rest and after 15 to 30 GI lasting up to 30 seconds.

Table 1. Demographic data of the 5 divers studied

Characteristic	Diver 1	Diver 2	Diver 3	Diver 4	Diver 5
Sex	Male	Female	Male	Male	Male
Age (years)	28	32	35	37	54
Height (m)	1.78	1.70	1.91	1.83	1.75
Weight (kg)	75.0	59.1	88.6	84.1	83.2
BMI	23.7	20.4	24.3	25.1	27.2
Comorbidities	None	None	None	None	None
Resting Vital Capacity (L)	7.56	4.56	6.17	6.49	6.26
(% of predicted)*	155%	119%	115%	117%	149%
Insufflation Vital Capacity (L)	9.59	5.65	6.45	8.42	7.47
(% of predicted)*	197%	149%	121%	152%	178%
Insufflation Volume (L)	2.03	1.09	0.28	1.93	1.21

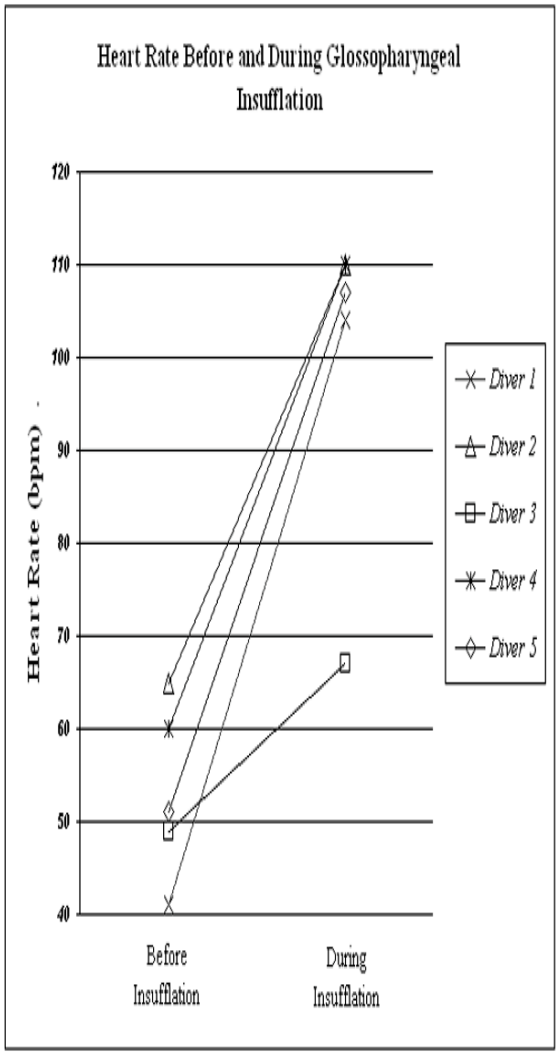
*Predicted vital capacities are from Knudsen

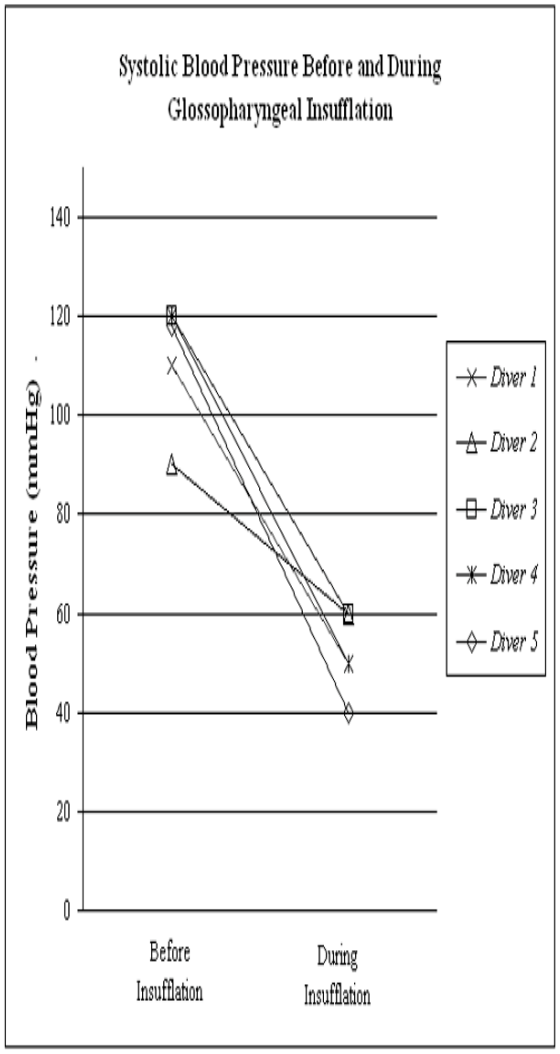
Parameter	At Rest		Insufflation		p-value
Heart rate (beats per minute)	53 ±	9.4	100 ±	18.4	0.005
Systolic blood pressure (mmHg)	112 ±	12.8	52 ±	8.4	0.002
Diastolic blood pressure (mmHg)	75 ±	9.5	0 ±	0	< 0.001
Left ventricular measures					
End-diastolic area (cm^2)	29.1 ±	4.3	15.7 ±	3.6	< 0.001
End-diastolic volume (cm^3)	103.5 ±	23.8	30.7 ±	12.2	< 0.001
End-systolic area (cm^2)	17.0 ±	1.9	11.8 ±	3.8	0.005
End-systolic volume (cm^3)	41.3 ±	11.1	21.8 ±	10.0	0.005
Ejection fraction	0.60 ±	0.07	0.30 ±	0.16	0.012

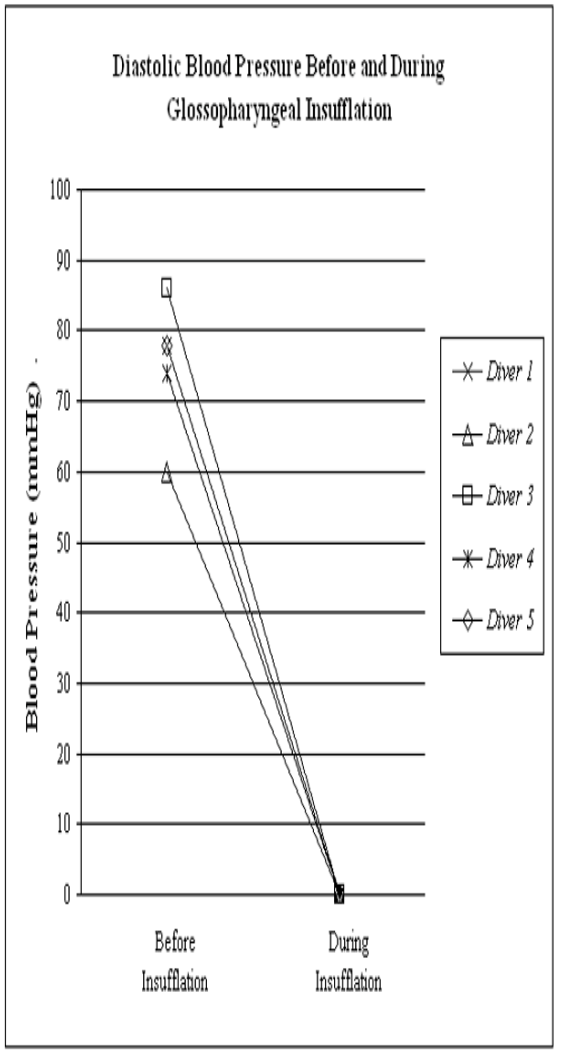
Right ventricular measures

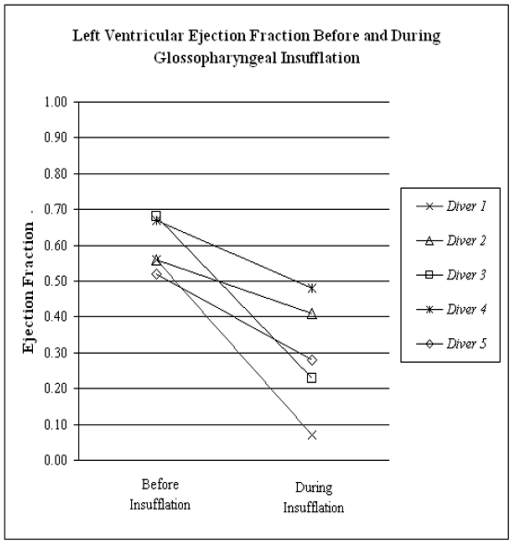
End-diastolic area (cm^2)	12.3 ±	4.6	18.3 ±	4.2		0.16
End-diastolic volume (cm^3)	20 ±	13.4	52 ±	19.7		0.078
End-systolic area (cm^2)	5.2 ±	2.8	14.0 ±	4.2		0.01
End-systolic volume (cm^3)	5.4 ±	4.4	30.7 ±	14.3		0.019
Ejection fraction	0.75 ±	0.11	0.39 ±	0.18	<	0.001

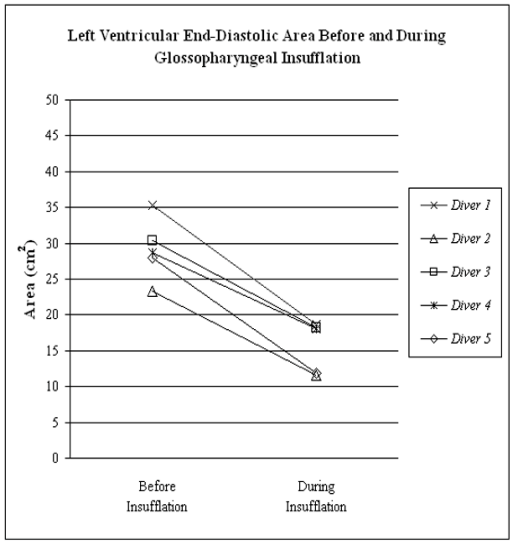
Values are means ± SD

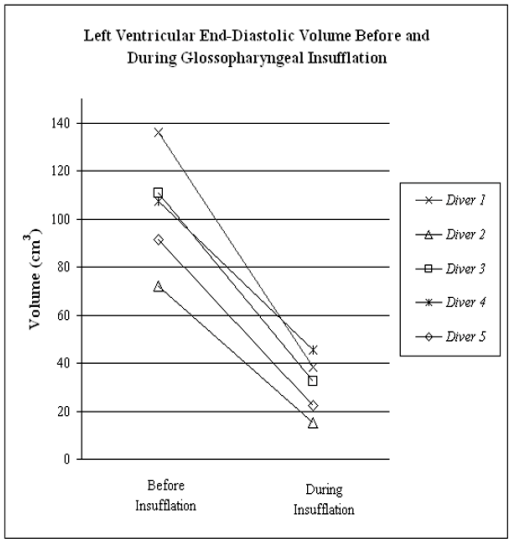

Heart Rate Before and During Glossopharyngeal Insufflation
Heart Rate (bpm)
120
110
100
90
80
70
60
50
40
Before Insufflation
During Insufflation
Diver 1
Diver 2
Diver 3
Diver 4
Diver 5

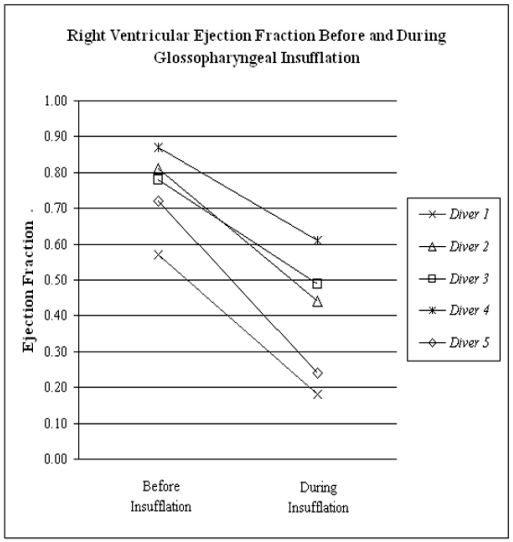

Systolic Blood Pressure Before and During Glossopharyngeal Insufflation
Blood Pressure (mmHg)
140
120
100
80
60
40
20
0
Before Insufflation
During Insufflation
Diver 1
Diver 2
Diver 3
Diver 4
Diver 5

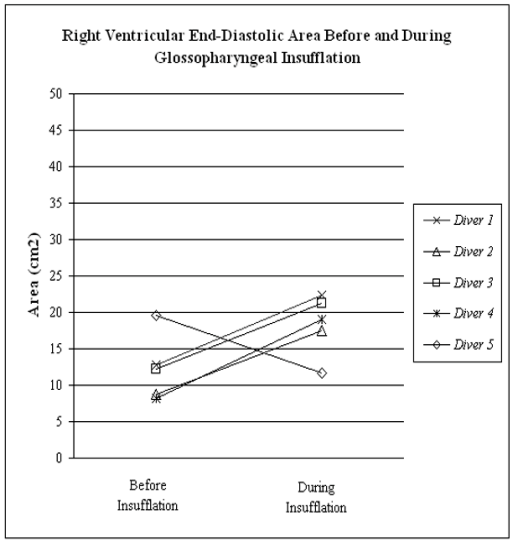

Diastolic Blood Pressure Before and During Glossopharyngeal Insufflation
Blood Pressure (mmHg)
100
90
80
70
60
50
40
30
20
10
0
Before Insufflation
During Insufflation
Diver 1
Diver 2
Diver 3
Diver 4
Diver 5

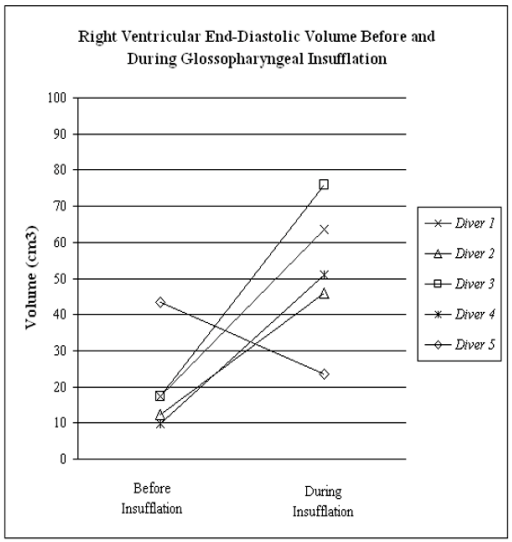

Left Ventricular Ejection Fraction Before and During Glossopharyngeal Insufflation
Ejection Fraction
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Before Insufflation
During Insufflation
Diver 1
Diver 2
Diver 3
Diver 4
Diver 5


Left Ventricular End-Diastolic Area Before and During Glossopharyngeal Insufflation
Area (cm2)
50
45
40
35
30
25
20
15
10
5
0
Before Insufflation
During Insufflation
Diver 1
Diver 2
Diver 3
Diver 4
Diver 5

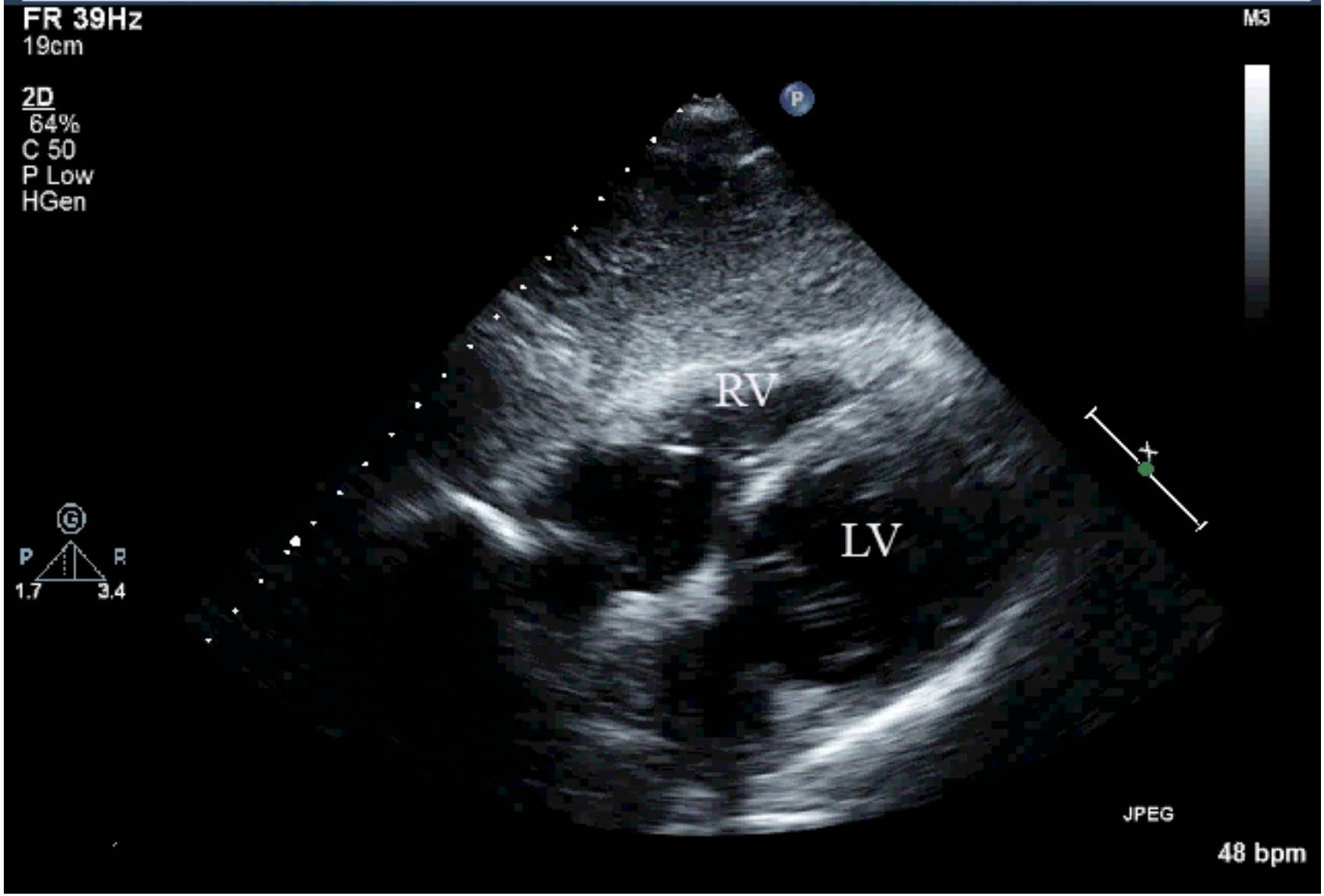

Left Ventricular End-Diastolic Volume Before and During Glossopharyngeal Insufflation
Volume (cm3)
140
120
100
80
60
40
20
0
Before Insufflation
During Insufflation
Diver 1
Diver 2
Diver 3
Diver 4
Diver 5

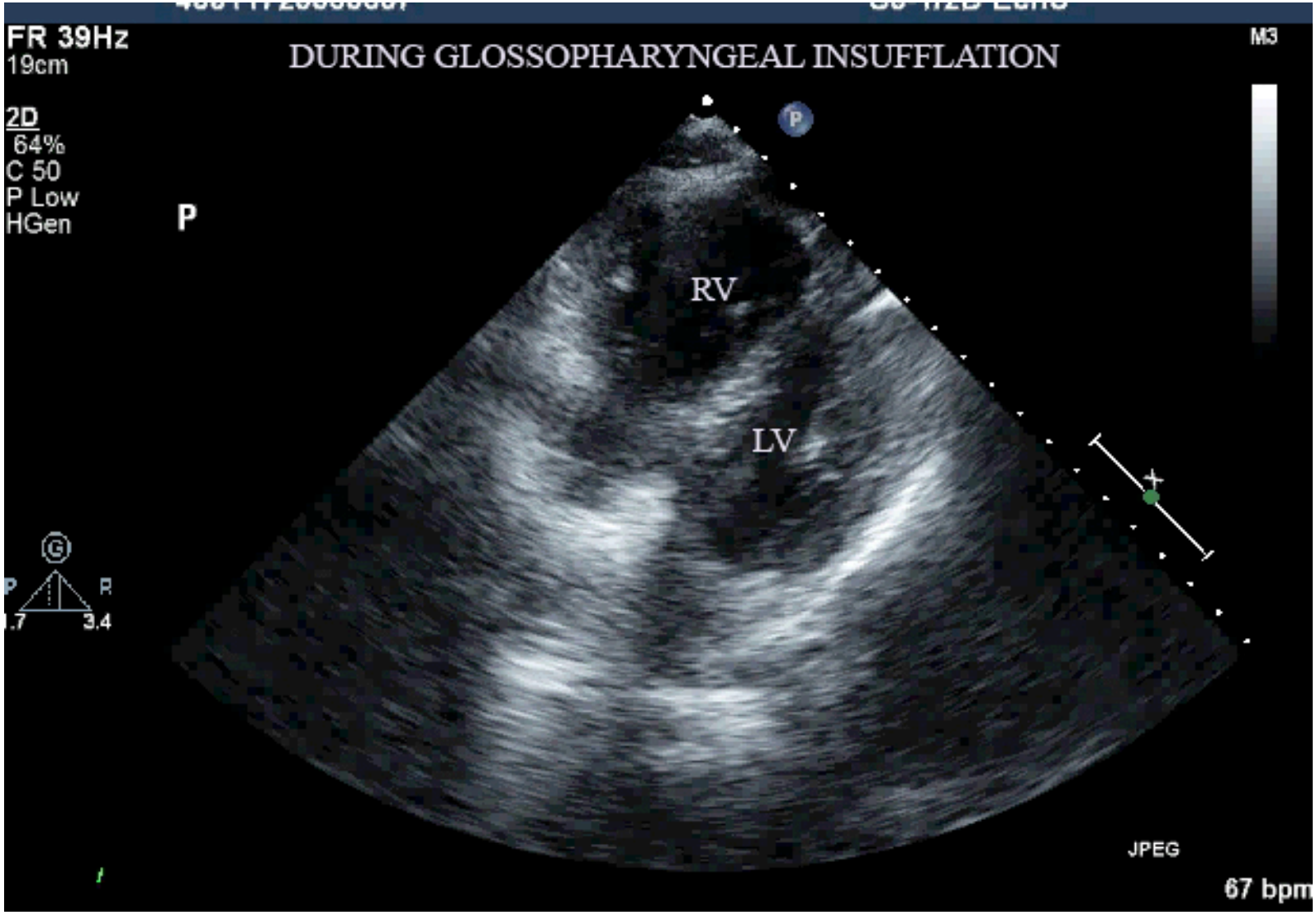

Right Ventricular Ejection Fraction Before and During Glossopharyngeal Insufflation
Ejection Fraction
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Before Insufflation
During Insufflation
Diver 1
Diver 2
Diver 3
Diver 4
Diver 5


Right Ventricular End-Diastolic Area Before and During Glossopharyngeal Insufflation
Area (cm2)
50
45
40
35
30
25
20
15
10
5
0
Before Insufflation
During Insufflation
Diver 1
Diver 2
Diver 3
Diver 4
Diver 5


Right Ventricular End-Diastolic Volume Before and During Glossopharyngeal Insufflation
Volume (cm3)
100
90
80
70
60
50
40
30
20
10
0
Before Insufflation
During Insufflation
Diver 1
Diver 2
Diver 3
Diver 4
Diver 5

BEFORE GLOSSOPHARYNGEAL INSUFFLATION




FR 39Hz
19cm
DURING GLOSSOPHARYNGEAL INSUFFLATION
M3
2D
64%
C 50
P Low
HGen
P
RV
LV
JPEG
67 bpm

CONCLUSIONS

- Hypotension during GI is associated with acute biventricular systolic dysfunction.
- The echo pattern of right ventricular systolic dysfunction is consistent with acute pressure overload.
- Left ventricular systolic dysfunction is likely due to ventricular interdependence

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BACKGROUND: Competitive breath -hold divers utilize a variety of techniques to increase lung capacity to achieve greater diving depths. One technique is glossopharyngeal insufflation (GI) GI has been thought to decrease venous return, causing a fall in cardiac output and arterial blood pressure (BP).

METHODS: Transthoracic echocardiography (TTE) was performed on 5 elite breath -hold divers at rest and during (GI) Blood pressure and heart rate were also monitored.

RESULTS:

Table 2. Mean hemodynamics and echocardiographic parameters before and during glossopharyngeal insufflation

Parameter	Diver State		p-value
	At Rest (value ± SD)	Insufflation (value ± SD)	
Heart rate (bpm)	53 ± 9.4	100 ± 18.4	0.005
Systolic blood pressure (mmHg)	112 ± 12.8	52 ± 8.4	0.002
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Left ventricular measures			
end-diastolic area (cm^2)	29.1 ± 4.3	15.7 ± 3.6	< 0.001
end-diastolic volume (cm^3)	103.5 ± 23.8	30.7 ± 12.2	< 0.001
end-systolic area (cm^2)	17.0 ± 1.9	11.8 ± 3.8	0.005
end-systolic volume (cm^3)	41.3 ± 11.1	21.8 ± 10.0	0.005
ejection fraction	0.60 ± 0.07	0.30 ± 0.16	0.012
Right ventricular measures			
end-diastolic area (cm^2)	12.3 ± 4.6	18.3 ± 4.2	0.16
end-diastolic volume (cm^3)	20 ± 13.4	52 ± 19.7	0.078
end-systolic area (cm^2)	5.2 ± 2.8	14.0 ± 4.2	0.01
end-systolic volume (cm^3)	5.4 ± 4.4	30.7 ± 14.3	0.019
ejection fraction	0.75 ± 0.11	0.39 ± 0.18	< 0.001

Conclusions: GI induces hypotension and causes right ventricular dilatation, biventricular cardiac failure and segmental wall motion abnormalities. The echocardiographic pattern of right ventricular systolic dysfunction is similar to that seen in acute pressure overload and the 1eft ventricular dys - function is likely due to ventricular interdependence.