Human vs AI-Based Echocardiography Analysis as Predictor of mortality in Acute COVID-19 Patients:

WASE-COVID Study

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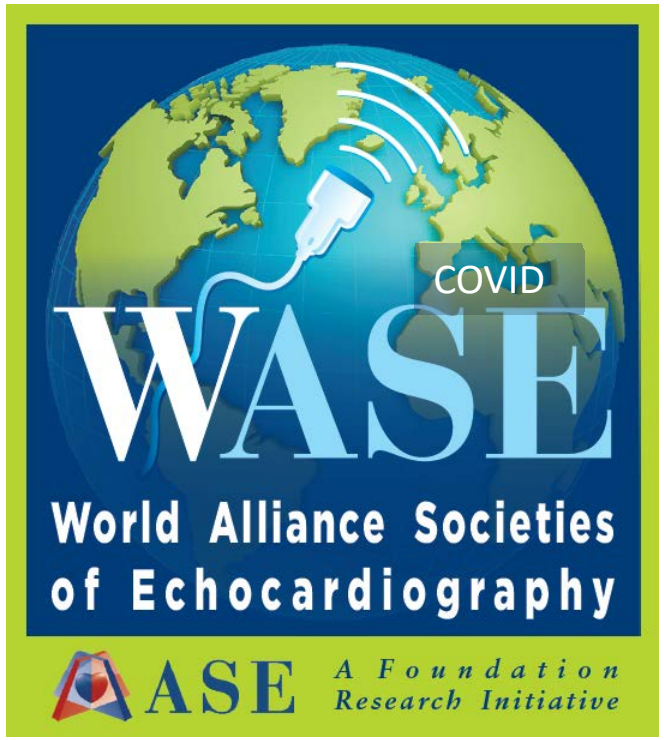

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Background

- Transthoracic echocardiography (TTE) has emerged as the leading cardiac imaging modality for patients admitted with COVID-19 infection
- Myocardial injury has been linked with poor outcomes, therefore an echocardiogram at admission may prove to be a powerful tool to predict death.
- The role of AI in cardiovascular imaging and specifically echocardiography is expanding, to facilitate image acquisition and analysis
- With reader-dependent technologies such as echocardiography, fully automated, AI-based analysis should result in lower variability of results than those obtained from human reads.
- With increased interpretation consistency, it is foreseeable that the use of automated measurements could improve the capacity to predict outcomes.

Aims

1- To explore association of echo variables with in-hospital mortality (Phase 1)

2- To describe the performance of machine learning -derived algorithms for prediction of death in patients admitted for acute COVID-19 infection and its incremental value to that of expert echocardiographer analysis (Phase 2)

WASE-COVID study Design

Observational, International

Phase 1- Retrospective Enrollment:

Adults Hospitalized for COVID-19 infection
(+) specific PCR or Antigen
Clinically-indicated echo

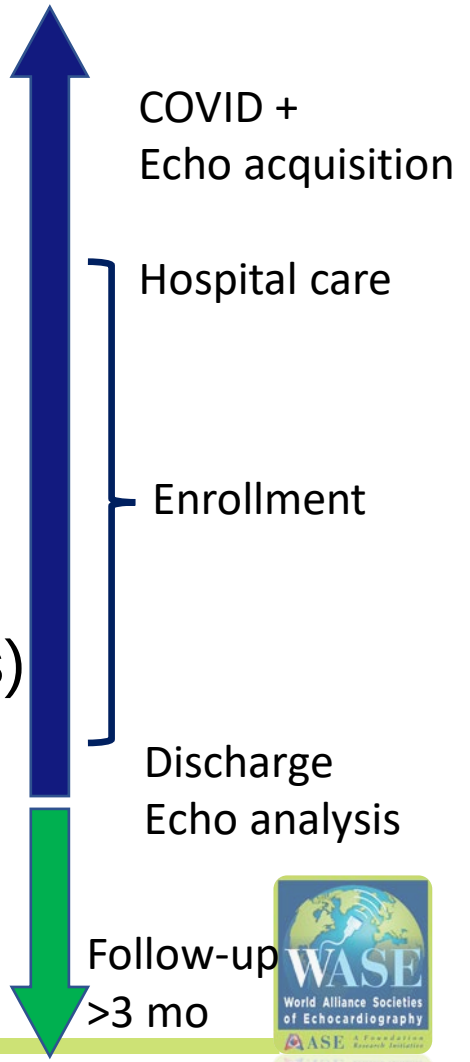
Echocardiogram:

Acquisition by center standards
Central, independent analysis (ASE Guidelines)

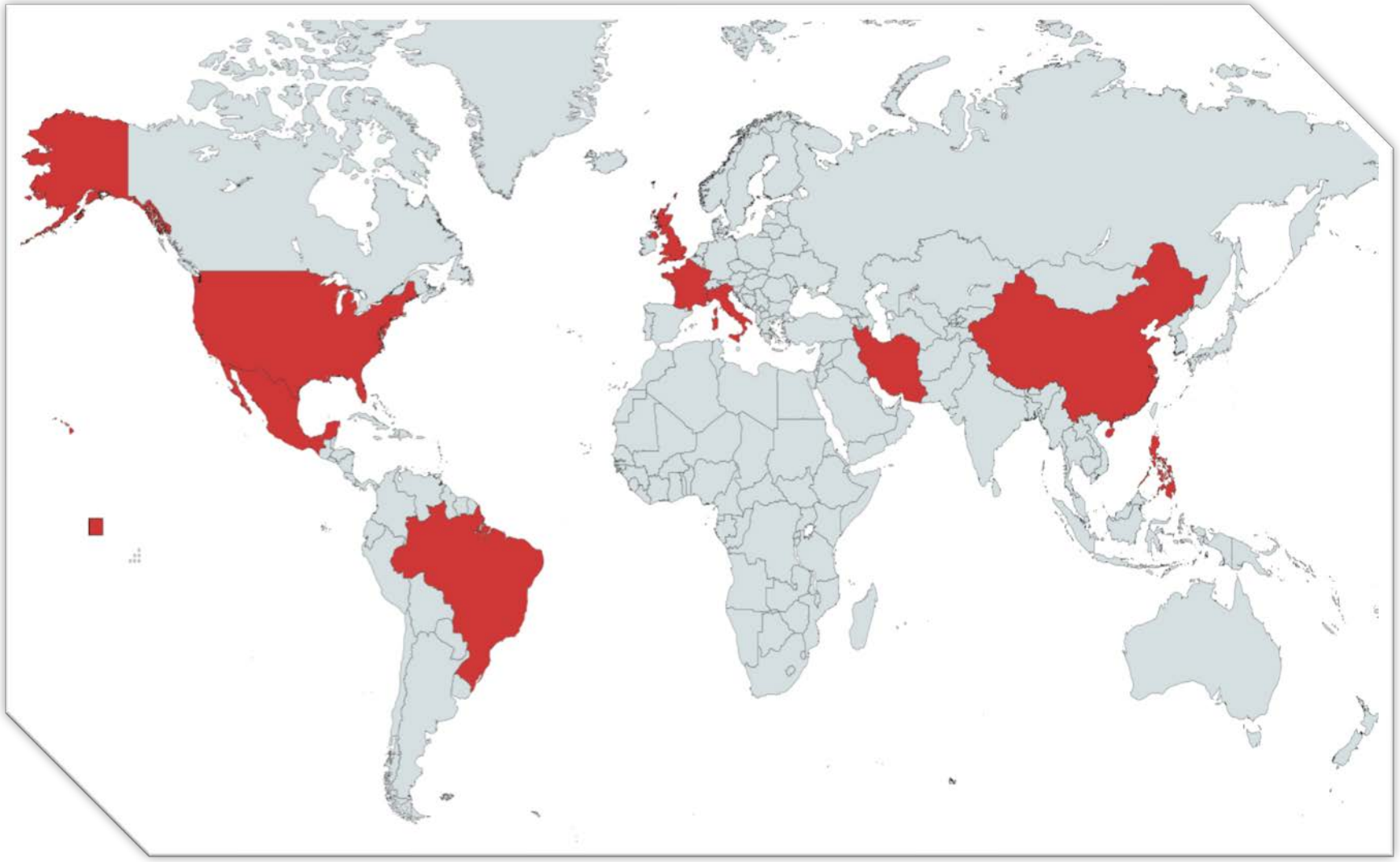
Phase 2- Prospective Follow-up > 3 months,

Medical encounter, med records, or phone call.

Outcome: All-cause mortality



n=870, 13 centers, 9 countries



USA x2

Mexico x2

Brazil

UK

France

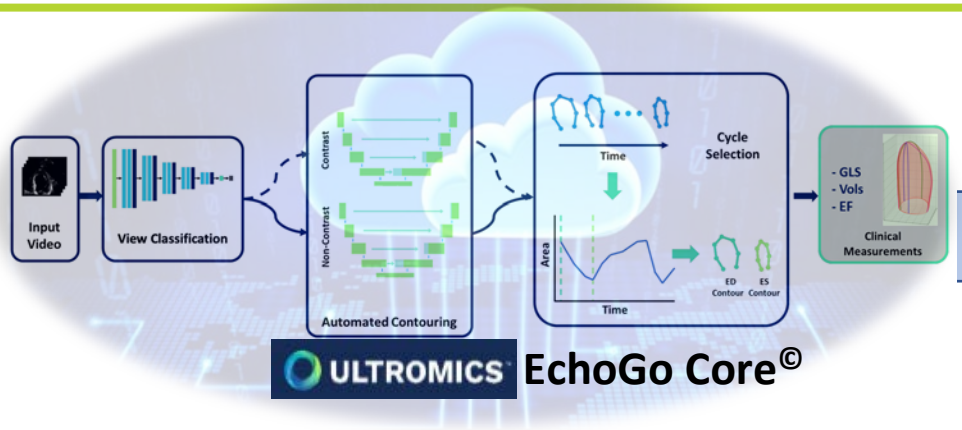
Italy x2

Iran x2

China

Philippines

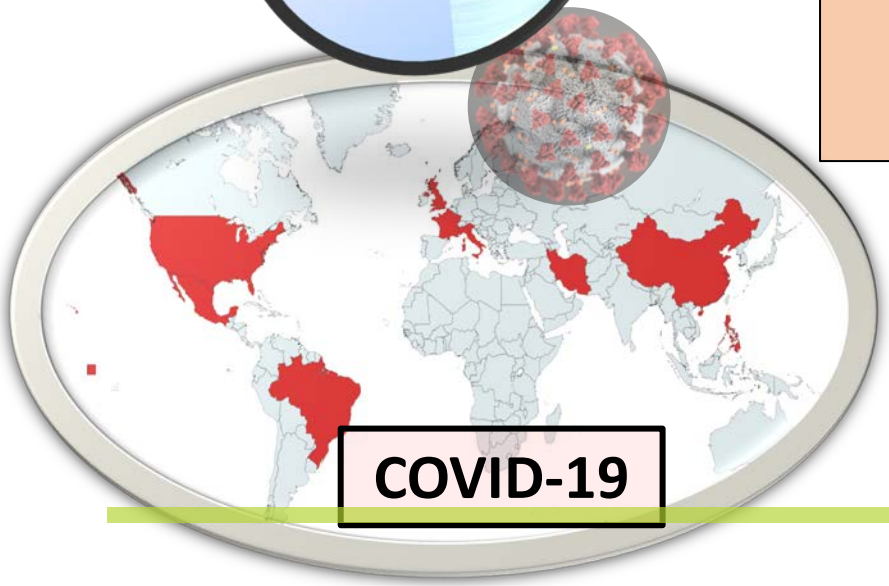
2D Echo analysis - LVEF, volumes, LV LS



Standard
Echo certified
readers
x 2

AI-based
LVEF and longitudinal Strain

LV EF and LS were
averaged from all 3 reads



WASE
World Alliance Societies of Echocardiography
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Population n=870

Age		59 ± 15
Sex, %	Female	43.8
Ethnicity, %	White non-Hispanic	22.6
	White Hispanic	17.5
	Black	15.6
	Asian	31.1
	Mixed	8.3
	Other	3.9
	Unknown	0.9
Blood pressure, mmHg	SBP	123 ± 19
	DBP	75 ± 12
Heart rate, BPM		85 ± 15
Status at initial TTE, %	ICU	46.2
	Mechanical Ventilation	27.1
	Hemodynamic support	17.8
Previous conditions, %	Heart disease	62.5
	Lung disease	14.6
	Kidney disease	9.2
	Hypoxemia	2.8

Echo characteristics

Characteristic	All
Left Ventricle (AI/human)	(n=722)
LV EF, %	60.2 (±12.3)
LVEDV, ml	107.9 (45.1)
LVESV, ml	44.8 (±33.7
LVLS, %	-18.7 (±5.3)
Right Ventricle (no AI)	(n=509)
RV FW strain, %	-22.8 (±6.1)
RV basal dimension, cm	4 (±2.5)
Pericardial effusion, (n, %)	145 (19.4%)

In-Hospital all cause mortality: 188 (21.6%)

LV LS was associated with in-hospital death, LVEF was not

(forward stepwise linear regression)

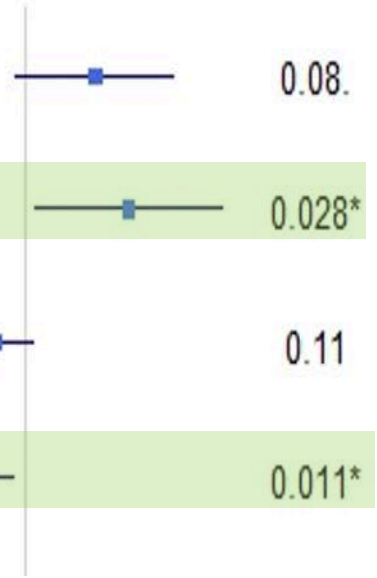
Multivariate Analysis		
Model 1 (LV)		
Age	1.118 [1.051, 1.219]	0.003
LV LS	**1.179 [1.045, 1.358]**	**0.012**
LDH (log)	6.17 [1.744, 28.734]	0.009
Previous lung disease	7.322 {1.561, 42.152]	0.015
Model 2 (RV)		
LDH (log)	5.691 [1.898, 20.844]	0.003
Age	1.080 [1.034, 1.141]	0.002
RVFWS	**1.136 [1.037, 1.256]**	**0.007**

Conclusions – Phase 1

- When measurements were averaged, LV LS, RVFWS, in addition to age, LDH, and previous lung disease were independently associated with in-hospital mortality, while LVEF was not.

Cox proportional Hazard Regression

Timepoint	Parameter	Method	HR	pval
In-hospital	LS	Manual	1.03	0.08.
		AI	1.05	0.028*
	EF	Manual	0.99	0.11
		AI	0.98	0.011*



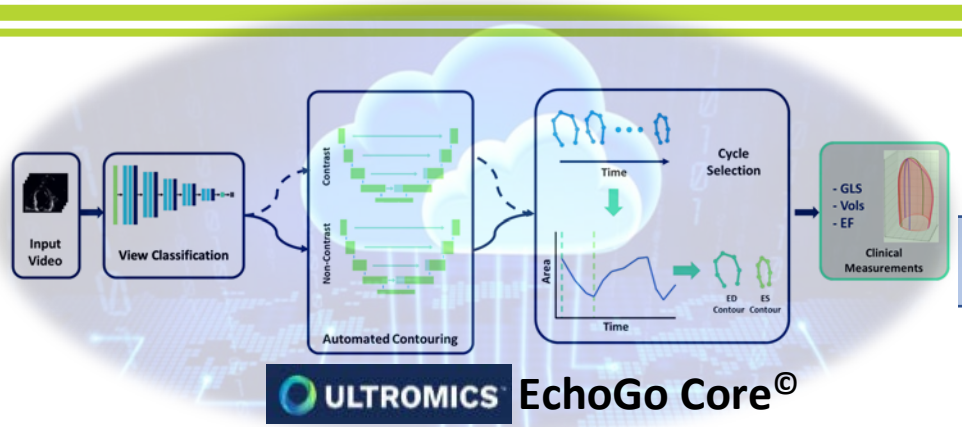
Hypothesis (Phase 2)

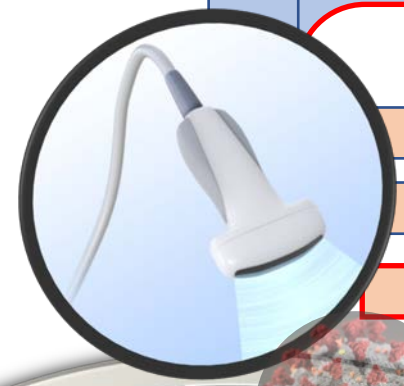
LVEF and LV LS obtained using AI-derived algorithms

will have **less** inter-reader **variability** and

will result in a **better predictor** of mortality than expert readers.

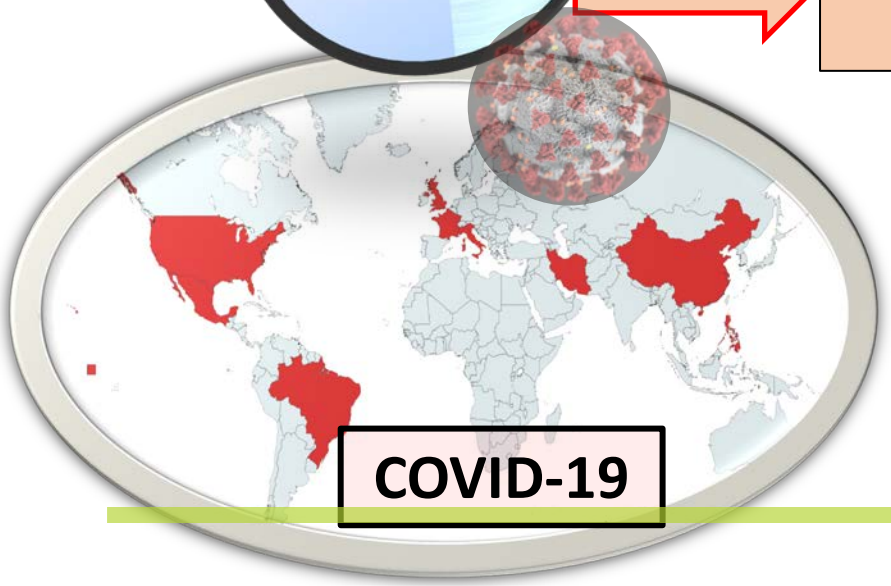
2D Echo analysis - LVEF, volumes, LV LS





Standard
Echo expert read
x 3

AI-based
LVEF and longitudinal Strain
x 2



Prospective Follow-up

476 TTE read was feasible both by manual and AI

230 (± 115) days of follow-up

Mortality was 27.4% (n=238: 188 in-hospital, 50 follow-up)

Variability – AI ↓

	Method	Frame selection	N	R (Pearson correlation) [95%CI]	ICC [95%CI]
LV EF	AI	All	385	0.853 [0.824, 0.878]	0.854 [0.824, 0.879]
	Manual		319	0.670 [0.605, 0.727]	0.655 [0.573, 0.722]
	AI	Same	49	0.996 [0.994, 0.998]	0.996 [0.993, 0.998]
	Manual		14	0.683 [0.239, 0.891]	0.680 [0.240, 0.886]
	AI	Different	336	0.832 [0.796, 0.862]]	0.832 [0.796, 0.862]
	Manual		305	0.671 [0.504, 0.728]	0.654 [0.569, 0.723]
LV LS	AI	All	385	0.789 [0.784, 0.824]	0.789 [0.748, 0.824]
	Manual		339	0.430 [0.336, 0.515]	0.430 [0.336, 0.515]
	AI	Same	49	0.987 [0.977, 0.993]	0.987 [0.977, 0.993]
	Manual		14	0.497 [<0.001, 0.813]	0.510 [<0.001, 0.814]
	AI	Different	296	0.761 [0.712, 0.803]	0.761 [0.712, 0.803]
	Manual		305	0.427 [0.330, 0,514]	0.426 [0.330, 0.514]

Factors responsible for Within-Patient Variance

Variable	EF		LS	
	Manual	AI	Manual	AI
	Variance (% total)	Variance (% total)	Variance (% total)	Variance (% total)
Frame	1.033 (1.40%)	2.362 (6.30%)	0.876 (2.74%)	0.588 (5.96%)
Operator	34.946 (47.39%)	0.067 (0.18%)	16.537 (51.81%)	0.140 (1.42%)
Reading Round	<0.0001 (<0.001%)	0.016 (0.04%)	0.115 (0.36%)	0.109 (1.11%)
Image quality	<0.0001 (<0.0001)	<0.0001 (<0.0001)	<0.0001 (<0.0001%)	<0.0001 (<0.0001%)

Variance in Manual was large and was mostly due to the operator

Variance in AI was small and was due to video frame selection

Prediction of mortality

Univariable Logistical Regression

Parameter	Mortality			
	In-Hospital		Follow-up	
	Odd Ratio [95% CI]	p-value	Odd Ratio [95% CI]	p-value
Echocardiographic parameters (Continuous)				
LVEF manual	0.985 [0.969, 1.003]	0.083	0.990 [0.975, 1.005]	0.187
LVEF AI	0.970 [0.952, 0.988]	0.001	0.974 [0.956, 0.991]	0.003
LVLS manual	1.035 [0.999, 1.074]	0.058	1.024 [0.991, 1.059]	0.155
LVLS AI	1.082 [1.035, 1.132]	<0.001	1.060 [1.019, 1.105]	0.004

Multivariable forward-step logistical regression

Parameter	OR [95% CI]	p-value
LVEF manual	0.983 [0.955, 1.012]	0.255
LVEF AI	0.968 [0.939, 0.997]	0.031
LVLS manual	1.038 [0.975, 1.108]	0.254
LVLS AI	1.096 [1.022, 1.179]	0.012

Limitations

- Patients were enrolled in a retrospective manner
- Not all echocardiograms could be quantified
- Echocardiograms did not include sufficient information to assess the left atrium, diastolic function and pulmonary pressures
- Findings may be applicable to patients with COVID-19, not necessarily to other patients
- However, if broadened to a wider patient population with better image quality, it is conceivable that AI contouring could be feasible in a much higher proportion of patients and therefore have more power

Conclusions (Phase 2)

- Automated quantification of LVEF and LVLS using AI minimized variability
- AI-based LV analyses, but not manual, were significant predictors of in-hospital and follow-up mortality.
- AI analysis of echoes could increase statistical power to predict outcomes, possibly requiring smaller sample sizes in clinical trials

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Thank You