Detection of Cardiac Arrhythmia at Very High Altitude Using a Wearable ECG Sensor

David R. Ohlson, DO¹, B. Shields Stutts, MD²
¹Co-Chief Resident – Bingham Internal Medicine Program – Blackfoot, Idaho ²Program Director - Bingham Internal Medicine Program – Blackfoot, Idaho

INTRODUCTION
The fact that sudden cardiac death (SCD) is the most common cause of non-traumatic death in males at high altitude has generated much interest in the effect of hypobaric hypoxia on heart rhythms. Consequently, there is little hard data on the subject. Recent small studies indicate that altitude is associated with brady and tachyarrhythmia, though not ventricular arrhythmia associated with SCD. In order to add to the body of knowledge, this pilot study used small, lightweight sensors to gather continuous ECG data on subjects at low, very high, and extreme altitude (Table 1).

METHODS
Wearable ECG sensors (Cardio2 Solo, Cardio2 Insight, USA) were used to gather 28 days of continuous cardiac data on 5 subjects before, during and after climbing Denali (20,310 ft./6190 m), the highest point in North America. Subjects were four males and one female ages 34.8±5.9 years (range: 28 – 41). All had a normal cardiovascular exam and gave written informed consent prior to study participation.

Subjects travelled to Anchorage, Alaska on May 14th, 2018 (Day 0) then drove to Talkeetna (348 ft./108 m). The following day (Day 1) the first sensors were applied. On Day 4 the team flew to the Talkeetna Glacier and hiked to Camp 1 at 7800 feet (2377 m). Subsequent camps were at 11,000 ft. (3353 m), 14,200 ft. (4328 m) and 17,200 ft. (5243 m). Of 5 subjects reached the summit (20,310 ft./6190 m) while one remained at the highest camp. Monitoring continued after subjects returned to their homes at altitudes less than 482 ft. (147 m) except for one, who resides at 4400 ft. (1341 m). Data from each of the 20 sensors was analyzed with proprietary software (Cardio2 Solo, v. 2.8.0.11). ECG’s were manually reviewed to confirm computer identified abnormalities and to find additional arrhythmic events.

RESULTS
Five subjects had continuous ECG monitoring for 26.8±2.8 days (range: 22.8–29.4). Total duration was 3,213 hours (134 days). Software was able to analyze 86% of this (2,761 hrs.) while the remaining 14% had poor signal quality.

One of five subjects had 39 non-conducted P waves during the study period. Figure 1 shows the altitude profile of the team and the number of these events, 34 occurred sleeping at the highest camp (17,200 ft./5243 m). This subject did not go to the summit before the last night sleeping there. The following night, the team slept at 11,000 ft. (3353 m) and there were an additional 4 dropped beats. For the next 10 days there were none, until the last night of monitoring when there was one additional dropped beat while sleeping at 482 ft. (147 m). These 39 non-conducted P waves resulted in pauses that averaged 2717 ± 416 ms (range: 2138 – 4043). The longest pause of 4043 ms was the sum of two consecutive non-conducted P waves and occurred on the fourth night sleeping at 17,200 ft. (5243 m) (Figure 2). PR prolongation preceded most pauses.

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DISCUSSION
The findings of this study are consistent with other recent work which has found pauses, supraventricular tachycardia, atrial fibrillation, atrial flutter, and ST depression at >4100 m (13,451 ft.). Pauses are the most common finding, seen in 8 of 15 subjects at >4000 m in one study. Based on the above, we would recommend avoiding sleep at very high altitude.8

REFERENCES